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# RESIDENTIAL AIR SYSTEM DESIGN

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# RESIDENTIAL

# AIR SYSTEM DESIGN

# MANUAL

2014 Edition

# NOTES

# FOREWORD

The Residential Air System Design Manual has been developed and published by the by the Heating, Refrigeration and Air Conditioning Institute of Canada.

Careful use of this Manual should result in satisfactory selection of heating and cooling equipment, system accessories and the design of air distribution systems for a designated residential building. However, the end result is in no way warranted by the Heating, Refrigeration and Air Conditioning Institute of Canada or any companies or any persons involved in the preparation or presentation of this manual.

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Heating, Refrigeration and Air Conditioning Institute of Canada

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| | |
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Special recognition is extended to Tom Dyer of Dyer HVAC Services Inc. for his contribution as technical writer and consultant to the project.

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# PURPOSE

This manual provides a method for designing residential forced air heating and cooling systems. The design information in this manual is considered "good engineering practice" and provides a supplement to meet the requirements of existing codes and standards such as the National Building Code, CSA Standard F280 and CSA Standard F326.

This manual is not intended to override the requirements of any applicable code or standard.

# SCOPE

a) The design procedures and tables of this manual apply only to residential forced-air systems. Heating and cooling loads shall be calculated in accordance with the HRAI Residential Heat Loss and Heat Gain Calculation Manual. The design methods in this manual are based on appropriate CSA Standards and industry recognized "good engineering practice".

b) This manual is not suitable for the design of small commercial systems. For the design of small commercial systems, use HRAI's "Small Commercial Air System Design" manual.

c) This manual provides worksheets to be used for the purpose of sizing residential forced air heating, cooling and ventilation duct systems.

d) The equipment specifications provided in this manual are for example purposes only and are not intended for field use. Specifications provided by the actual equipment manufacturer should be used in the field.

# 1 BASIC CONCEPTS

## 1.1 Air flow

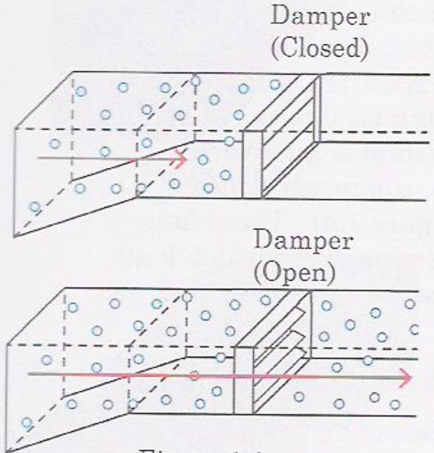



Figure 1.1

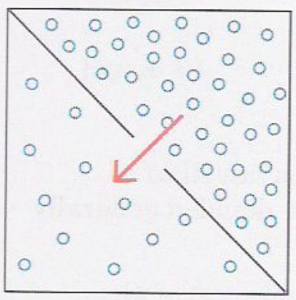


Figure 1.2

### 1.1.1 Why does air flow?

Air flow will only occur when there is a difference in air pressure. For example, in a furnace plenum with a closed trunk damper, no air will flow through the trunk duct; air Static Pressure on plenum take off side of the trunk is higher than the air pressure on the other side. Once the trunk damper is opened the Static Pressure is converted to pressure of flow (Velocity Pressure), see Figure 1.1.

### 1.1.2 What is air pressure?

Air pressure is relative to the concentration of air in a given space. When two air spaces of the same size are compared, the one having a greater number of air molecules will have the greater air pressure and weight. Therefore, air will flow from the space having more air molecules to the space having less molecules, see Figure 1.2.

### 1.1.3 Measurements of air flow

CFM (cubic feet per minute) is a volume measurement. A fan operating at 100 CFM draws in and pushes out 100 cubic feet of air each minute.

FPM (feet per minute) is a velocity measurement. In an air stream moving at 500 FPM, the air would travel 500 feet each minute.

CFM and FPM are directly related. For a duct of constant cross-sectional area, the CFM increases or decreases proportional to the FPM. As an example, when air passes from a trunk duct to a branch duct the CFM in the trunk duct will decrease. As long as the cross-sectional area of the trunk duct remains the same, a proportionate decrease in FPM will occur, see Figure 1.3.

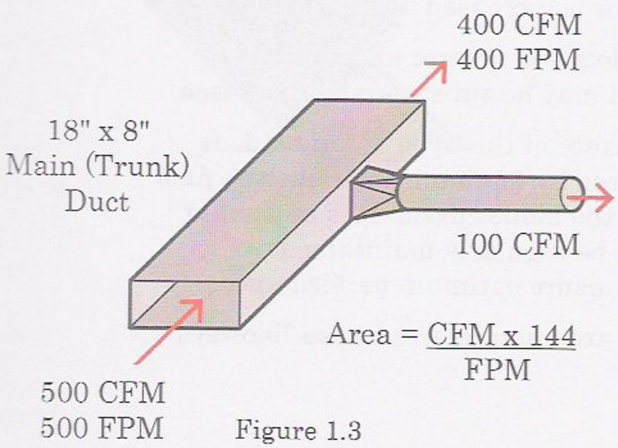



Figure 1.3

# 1.2 Fans

### *1.2.1 Fans*

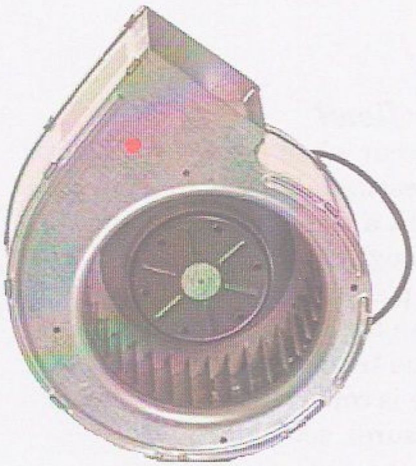


Figure 1.4

With a gravity system, warm air will not adequately migrate to the lower areas of a house (basements) nor can cool air (air conditioning) be distributed in summer. To overcome these problems, a fan is used. The most common type of fan used for a residential heating and cooling system is a forward curved centrifugal fan, commonly called a "squirrel cage fan" (Figure 1.4). These fans have the following characteristics which lend themselves well for the use of heating and cooling systems:

- produce low to medium pressures
- move large quantities of air
- cost effective
- relatively quiet
- require clean air flows

It should be noted that if the fan RPM (revolutions per minute) are doubled generally the following will happen:

- the CFM (cubic feet per minute) of air delivered doubles
- the SP (static pressure) is quadrupled
- the power requirement (horsepower) of the drive motor is increased to eightfold
- the air velocity is greater and therefore noise level may be substantially increased

The performance of this type of fan blade is greatly reduced by foreign matter such as dust collecting in the blade curve. It is important that this fan be regularly maintained (cleaned) to ensure optimum performance.

**Note:** Fans are often referred to as "blowers"

### 1.2.2 *Fan Drives*

Two common types of fan drives are:

- the direct drive where the armature of the motor is also the shaft of the fan (Figure 1.5)
- the belt drive where the motor is connected to the fan by pulleys and belts (Figure 1.6)

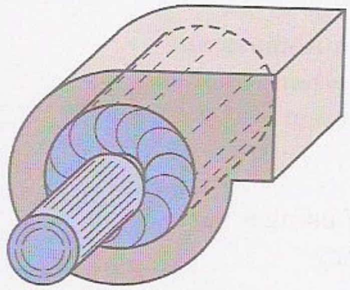


Figure 1.5

Direct drive fans are normally multi- speed, giving a choice of 3 or more speeds depending on how the motor is wired. These fans are more efficient than belt driven fans when producing the same pressures and moving the same volume of air. There are no belts to replace. However, repair, parts and labour tend to be more expensive.

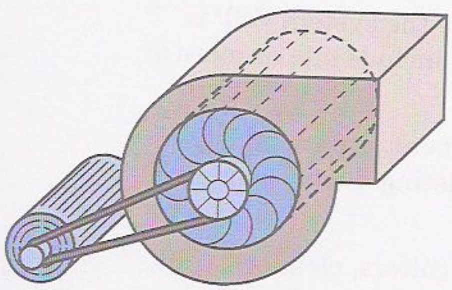


Figure 1.6

Belt drive fans were popular in the past, but they are no longer commonly used in residential air systems. They are normally used with 1 or 2 speed motors. By changing or adjusting belts and pulleys, a wide variety of pressures and air volumes can be achieved. Fan belts need to be replaced from time to time and the fan motor assembly is much bulkier than a direct drive.

### 1.2.3 *Fan Motors*

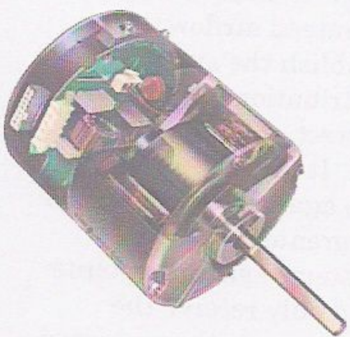


Figure 1.7

Electronically commutated motors (ECM), also known as brushless DC motors (Figure 1.7), are now commonplace with heating and air-conditioning appliances. These motors are available as either constant torque (non-variable speed) or variable speed models. As a note, variable speed models can provide pre-determined airflow within a variable range of system operating pressure. Air moving systems using variable speed type of motor drive method are virtually guaranteed to deliver the design airflow provided the operating system static pressure does not go beyond the limits set by the equipment manufacturer.

Features:

- EC motors are brushless DC motors using built-in AC-DC inverters
- soft starting (slow wind-up)

- available as constant torque (non-variable speed) or variable speed models
- variable speed models automatically compensate (ramp up) when sensing a change in operating system static pressure

Additional advantages of using a variable speed brushless DC motor:

Having a variable speed fan motor that delivers the required cfm within a range of static pressure is a distinct advantage. This is particularly true where the system ESP is difficult to predict and include one or more of the following:

- Retro-fit or replacement situations where part or all of the existing ductwork may be hidden.
- System accessories (filters, cleaners, coils, dampers and humidifiers) are installed after the initial design installation.

### *1.2.4 Fan Drive Impact*

While it may appear that systems using a variable speed motor would be exempt from using a proper duct design technique, even with this virtually guaranteed airflow, it is just as important to establish the system operating pressures, distribution path and duct sizing to ensure correct air delivery to each room, area or zone. It must be realized that the fan will operate against a variation in pressure at the point of greatest system resistance. All other system resistance points in the duct system would only receive the correct airflow if they were correctly evaluated and sized accordingly.

### *1.2.5 Heating Speed Selection*

Equipment manufacturers with this type of speed control have given designers the option of a much greater selection of air volume but within a static pressure limitation.

Designers must now determine which speed tap to use for an appropriate design and in doing so, must consider the following:

- Should the speed selection be based on High or Low stage? The intent of this type of furnace is to size based on High output. Therefore, the speed selection and airflow should also be based on High stage. This of course helps ensure that the duct sizing would always be sufficiently large enough to accommodate the highest airflow within the recommended velocity limits.
- Is the temperature rise too high or too low? Some homeowners, particularly in retrofit applications, may desire a warmer delivery temperature (higher temperature rise) and therefore a lower number speed tap may be used.
- Well insulated larger homes with low heat loss would require a furnace with lower output. In this situation, a designer may choose a higher speed to provide adequate comfort air circulation throughout the home. This would require a previous calculation based on 1-1/2 to 2-1/2 air re-circulations to establish a desired air volume range.
- Some contractor/designers may want to take advantage of reduced duct costs. In this case, a designer would choose a lower speed with lower volume, thereby creating smaller trunks and branches.
- Equipment manufacturers offer **temperature rise adjustment.** This is simply an adjustment to fan speed. Typically an increase in temperature means lower airflow and a decrease in temperature rise results in a lower airflow. Airflow due to temperature rise can be determined using the following formula:

$$\text{CFM} = \frac{\text{Btuh (output)}}{1.08 \times \Delta T}$$

### *1.2.6 Cooling Speed Selection*

Cooling speed selection is based on the target airflow typically, number of tons × 400 cfm. With the varied selection of speed and speed adjustments, the target airflow is more likely to be obtainable. This should also help to ensure that the appropriate amounts of both sensible and latent heat are removed simultaneously. It may also be noted that with some refrigerants, equipment manufacturers may recommend airflow rates between 350 and 450 cfm.

### *1.2.7 Speed Adjustment Selection*

Speed adjustment (fine tuning) generally up to + or - 15% of selected fan speed now provides the designer/commissioner with the luxury of choosing similar heating, cooling and circulation airflow speed settings without the expense of additional relays and wiring.

### *1.2.8 Static Pressure Limitations*

Heating system static pressure may be limited to 0.5" ESP (External Static Pressure). This limited static pressure may be used to design a system without an A/C coil (heating only) or a system with cooling using the dry or wet coil. In both of the previous cases, careful use of the ESP by the designer should result in a satisfactory system design.

**Note:** Fan or blower performance data can be found in manufacturer's specifications and should always be referred to when determining system fan speed, airflow, ESP and H.P. Generic example specifications are shown in Appendix A of this manual.

## 1.3 Pressures

Within a residential heating and cooling system, there are 5 measurements of pressure which a designer must understand. These are static pressure, velocity pressure, total pressure, external static pressure and pressure drop. All pressures for residential equipment and duct systems are measured in inches of water column (in. w.c.)

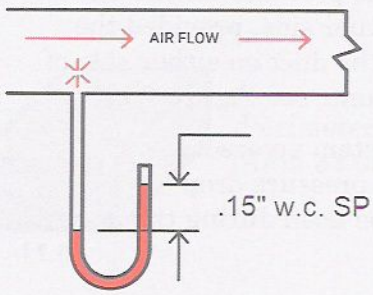



Figure 1.8

### *1.3.1 Static pressure (SP)*

Static pressure (SP) is the pressure pushing outward or inward on the walls of a duct. This pressure measurement is taken at right angles to the air flow, see Figure 1.8.

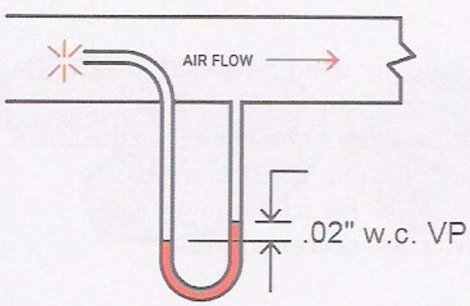



Figure 1.9

### *1.3.2 Velocity pressure (VP)*

Velocity pressure (VP) is the pressure exerted by the flow of air along the duct. This pressure measurement is taken directly into the air flow. (VP) can also be expressed as ***(TP – SP)***, see Figure 1.9.

### *1.3.3 Total pressure (TP) (SP +VP =TP)*

Total pressure (TP) is the sum of static pressure and velocity pressure. It should be noted that, as duct size and shape are changed at a particular point in a duct system, the static pressure may be converted to or from velocity pressure but the total pressure will remain constant. Total pressure is consumed by the resistance of the duct system and accessories. In other words, the total pressure will decrease the farther we are from the fan. This is true for both supply and return ducts.

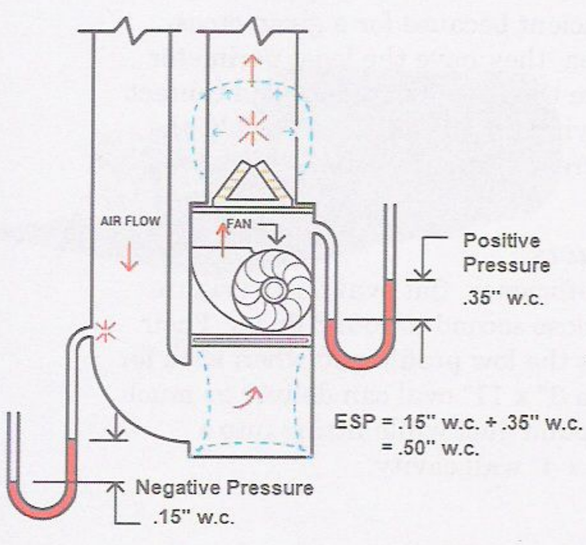



Figure 1.10

### *1.3.4 External Static Pressure (ESP)*

External Static Pressure (ESP) is the term used by the equipment manufacturers to express the total energy available to overcome the resistance of the entire HVAC system. This would include equipment and duct accessories,

such as (coils, filters, grills, dampers, etc.) and all ductwork within the system, see Figure 1.10.

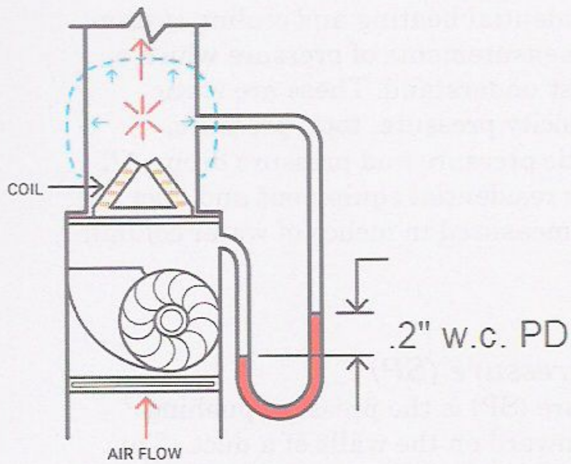


Figure 1.11

### *1.3.5 Pressure drop (PD)*

Pressure drop (PD) is the reduction in total pressure caused by components added to a duct system such as filters, registers, grills, and coils. The measurement of pressure drop is the difference in static pressure on one side of the component to the other side, provided the cross-sectional area of the duct on either side of the component is the same, see Figure 1.11.

**Note:** Most HVAC system accessory manufacturers provide pressure drop information that may be used during the design process.

## 1.4 Ducts

The ducts that are typically used for Residential Air System design are described below. The ducts shown in the illustrations on the left side all have the same air handling ability. They are said to be "equivalent sizes for friction loss and capacity" and not for cross- sectional area.

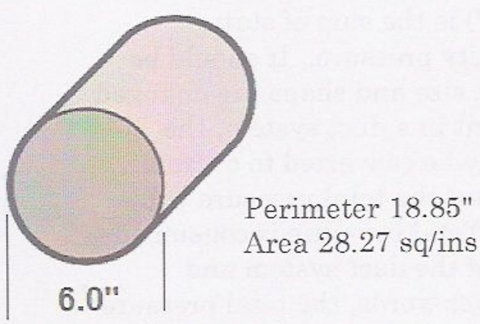


Figure 1.12

### *1.4.1 Round Ducts*

Round ducts (Figure 1.12) are the most efficient and strongest of all the duct shapes. They are the most efficient because for a given cross-sectional area, they have the least perimeter and therefore the least surface area in contact with the moving air-stream. As a result, the moving air creates less frictional resistance.

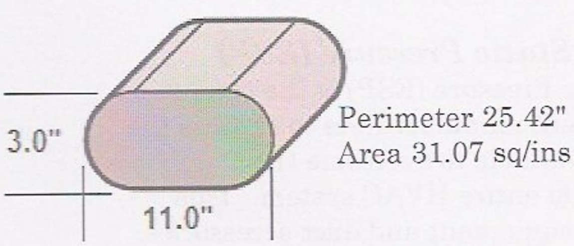


Figure 1.13

### *1.4.2 Oval Ducts*

In terms of efficiency, flat oval ducts (Figure 1.13) are a close second to round ducts. Their advantage is the low profile and when used for wall stacks a 3" x 11" oval can deliver as much air as a 6" round duct while fitting into a standard 2" x 4" wall cavity.

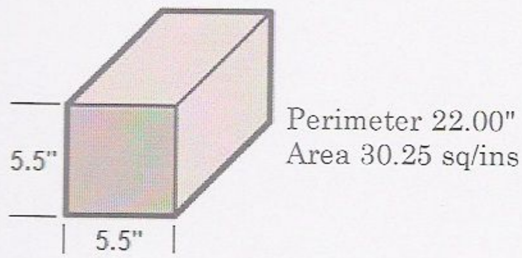



Figure 1.14

### 1.4.3 Square Ducts

Square ducts (Figure 1.14) are the most efficient and strongest of four sided ducts. Square ducts have an aspect ratio of 1:1 (width to depth). Square ducts also have a shorter width and depth for the same diameter of a round duct when carrying a similar amount of air and will fit more conveniently into structural cavities of a house.

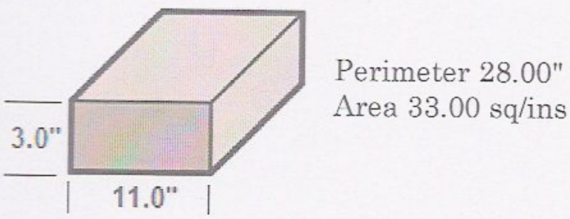



Figure 1.15

### 1.4.4 Rectangular Ducts

Rectangular ducts (Figure 1.15) are the least efficient of the common duct shapes. As the aspect ratio increases, the efficiency decreases and the cost increases. SMACNA (Sheet Metal and Air Conditioning Contractor's National Association) recommends aspect ratios of 2:1 with a maximum of 4:1.

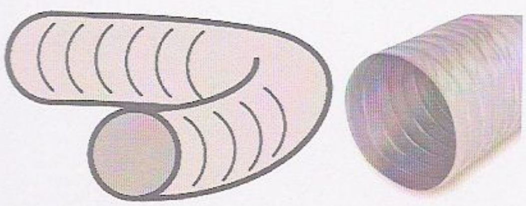


Figure 1.16

### 1.4.5 Flexible Ducts

Flexible Ducts (Figure 1.16) are a type of round duct which is used in place of round metal ducts for vibration isolation and ease of installation. It is generally accepted that the typical resistance of flexible ducts is double the resistance of round metal ducts when installed according to manufacturer's instructions. Flexible ducts should be used only in short runs because of this greater resistance to air flow.

Figure 1.17

### 1.4.6 Acoustically Lined Ducts

Acoustical lining (Figure 1.17) is used in ducts to reduce the amount of fan and air flow noise transmitted through the duct system. Acoustical lining reduces the cross-sectional area of a duct and, because of the lining's rough surface; it also adds considerable resistance to the duct system. Adding duct lining will increase friction loss and may increase velocity when not compensated for.

# 2 DESIGN REQUIREMENTS

## 2.1 General

Systems should be designed in accordance with the general requirements of this manual, using the appropriate reference tables and employing the following basic stipulations.

### *2.1.1 System Zoning*

The need for a zoned system for larger homes, or homes with special heating/cooling requirements should be considered. One of the primary reasons for zoning is when the heat loss or gain for a section of a home may vary widely from the heat loss or gain of another section of the home. For instance, consider a family room with a large glass area facing west. In the afternoon this family room may become much warmer than the rest of the home due to the radiant heat through the glass. If a zoned system was used, with the family room as a separate zone, then additional cooling could be provided to the family room when required, without over cooling the rest of the home.

When a zoned system is to be used, the supply outlets to each zone shall be provided with their own independent source of heat. Where a single heating unit is employed, this would mean a separate trunk duct to serve the branches of each zone.

Where a zoned system is used, the zone controls should be installed and operated according to the zone control manufacturer's instructions and under all operating conditions the following shall apply:

- excessive negative pressure is not created in any area of the home because of the zoning.
- the temperature rise through the heating equipment is within the limits set by the heating equipment manufacturer.
- the velocity of the air within the duct system is not beyond the limit set in Appendix C table C 2 of this manual
- the airflow over a cooling coil will at least meet the manufacturer's minimum required airflow.

**Zone System Operation**

Zone systems usually operate in the following manner:

The **"System Controller"** is at the center of the operation and receives signals from the LAT sensor and Zone thermostats, which in turn controls the HVAC unit and signals the zone dampers to open and close.

The **"Leaving Air Temperature Sensor"** senses the temperature of the air as it leaves the plenum. Signals are sent back to the controller, the signal information is used to control cycling of the equipment and prevent operation when the temperatures exceed normal operating conditions. Manufacturers would usually suggest placing the LAT sensor away from influencing heat exchangers or evaporator coil temperature.

**"Bypass Damper"** is a pressure relief device used to prevent over pressurizing of system ducts. This damper either barometric (weighted) or the static pressure sensitive type is placed in a duct connected from the supply plenum to the return plenum or trunk duct. Dampers are available either round or rectangular and are sized according to the total system volume (cfm) minus the smallest system zone volume. The bypass damper will sense the system pressure and gradually open in response to the zone closures. This ensures that even when the last zone is calling for airflow, there is sufficient bypass air to avoid system pressurization.

**"Zone Dampers"** operate singularly or as a group of dampers that open or close a zone. These dampers are signaled by the controller in response to the zone thermostat. Zone dampers are available in a number of round or rectangular sizes for both trunk and branch systems. Zone dampers are two position dampers and although adjustable, branch balancing dampers may still be required (check with zone control manufacturer).

**Note:** If the smallest available zone damper is too large for the branch duct, place reducer after the zone damper to comply with original duct size.

**Note:** Zone dampers should be placed a minimum of 6' away from the supply diffuser, this should help reduce noise transmission created by turbulence at zone damper.

**"Zone Thermostats"** are placed in each of the required zones. Each zone thermostat will monitor the zone temperature set points and send signals back to the system controller for opening or closing of the zone dampers.

**"Additional Features "** Some zone control manufacturers offer additional features such as outside air (ventilation) control and in some cases a fire protection control which closes all zone dampers in response to a fire sensor.

**Note:** System zoning must not be seen as an excuse to avoid system designing. Zoning alone in no way ensures that the correct amount of air will be delivered to the conditioned space. While the zone thermostat may be satisfied, other rooms in the same zone (without thermostats) may not be at the same temperature. Ducts therefore must be sized by conventional methods to ensure the correct amount of air supply to each branch duct, thus ensuring complete temperature control.

### Residential System Zoning (System Type 1)

The following (Figure 2.1) is a typical example of a two zone (basement & main floor) system. Each branch run has a zone damper which responds to the appropriate zone or area thermostat. With this arrangement, both main floor and basement may be controlled at different temperature levels.

With this type of zoning system, trunk and branch ducts will have to be located in the unfinished portion of the basement to provide continued access to zone dampers.

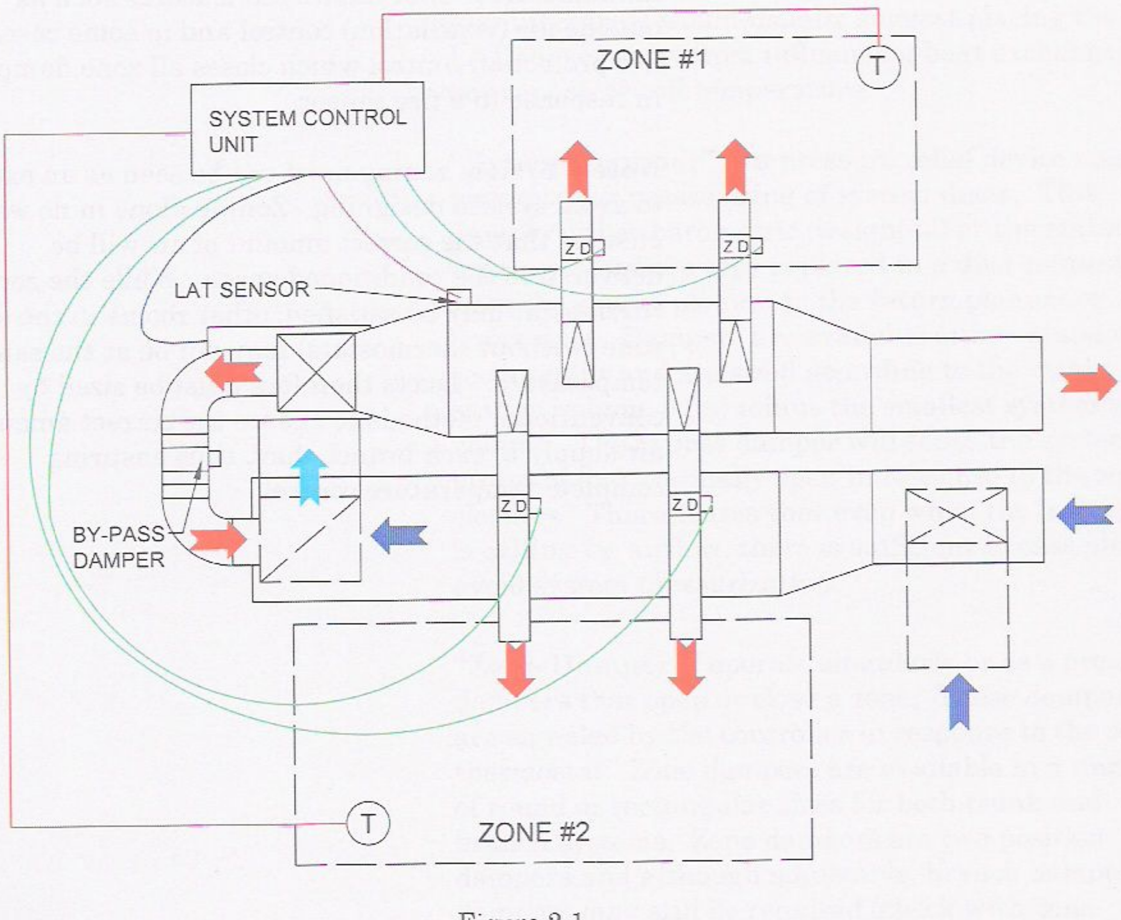



Figure 2.1

### Residential System Zoning (System Type 2)

The following (Figure 2.2) is a typical example of a three zone (basement, main floor, second floor or addition) system, each trunk duct has a zone damper which responds to the appropriate zone or area thermostat. With this arrangement, basement, main floor, second floor or addition may be controlled at different temperature levels.

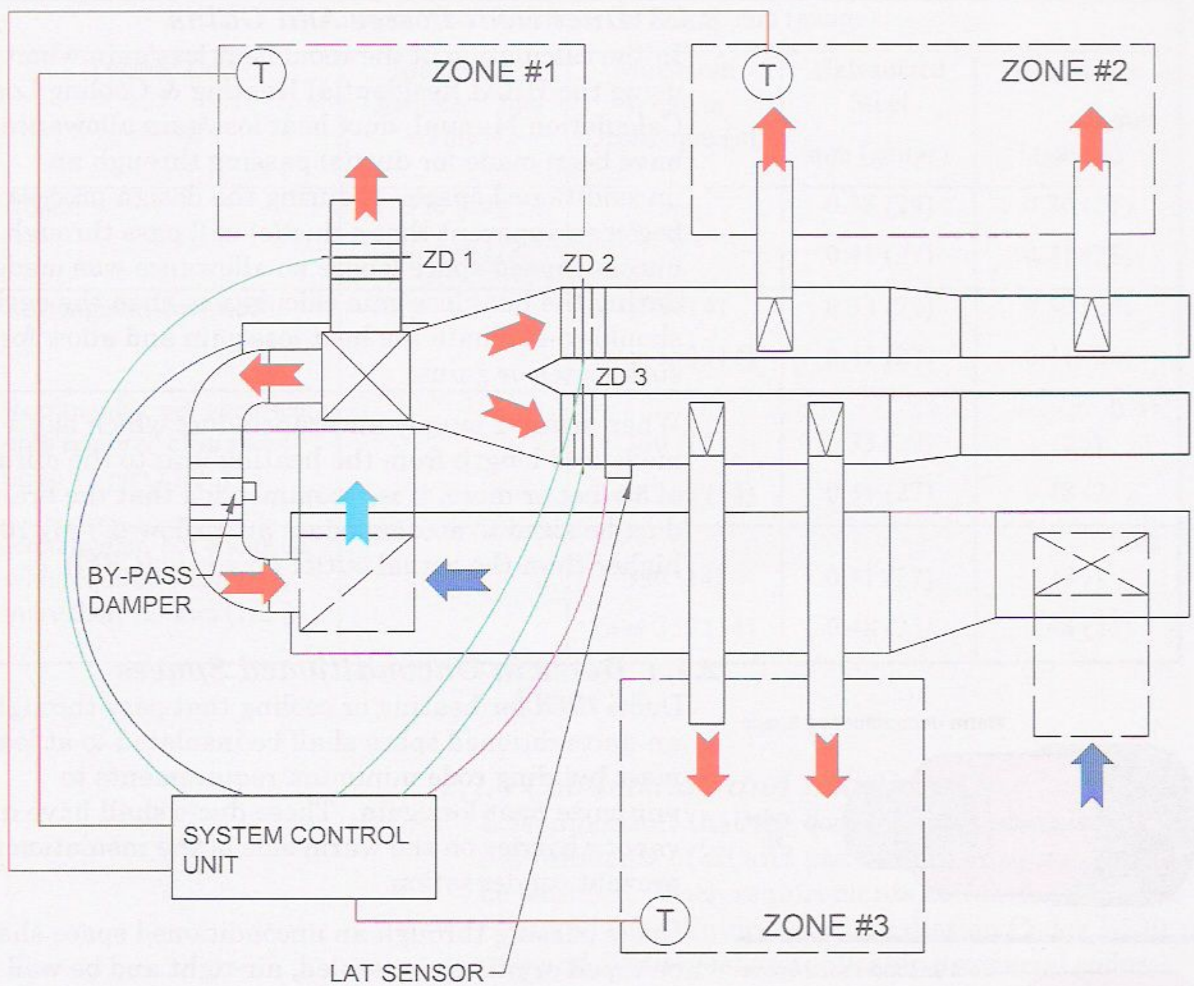



Figure 2.2

### *2.1.2 Duct Sizing*

The air distribution ducts shall be sized to carry adequate air volume for comfortable air circulation with a temperature rise approved by the equipment manufacturer.

In areas where the summer design dry bulb temperature exceeds 81 °F (27 °C), the air volume required for summer cooling shall be incorporated into the air system design.

### *2.1.3 Duct Heat Losses And Gains*

In the calculation of the room heat loss/gain when using the HRAI Residential Heating & Cooling Load Calculation Manual, duct heat loss/gain allowances have been made for duct(s) passing through an unconditioned space. If during the design process it becomes apparent that a duct(s) will pass through an unconditioned space where no allowance was made during the heat loss/gain calculation, then the designer should re-evaluate the heat loss/gain and allow for such losses or gains.

When sizing a supply air branch duct which has a measured length from the heating unit to the diffuser of 50 feet or more, it is recommended that the branch duct be sized to accommodate an airflow (CFM) 10% higher than the actual outlet flow rate (CFM).

### *2.1.4 Ducts in Unconditioned Spaces*

Ducts used for heating or cooling that pass through an unconditioned space shall be insulated to at least meet building code minimum requirements to minimize heat loss/gain. These ducts shall have a vapour barrier on the warm side of the insulation to prevent condensation.

Ducts passing through an unconditioned space shall be taped or otherwise sealed, air-tight and be well supported.

The most common method of meeting these requirements is shown in Figure 2.3. In both of these drawings the outside (unconditioned) space would be representing a duct passing through the attic or crawl space.

With a cool space, the sealed duct becomes the vapour barrier; this must be sealed to prevent moisture from penetrating the insulation.

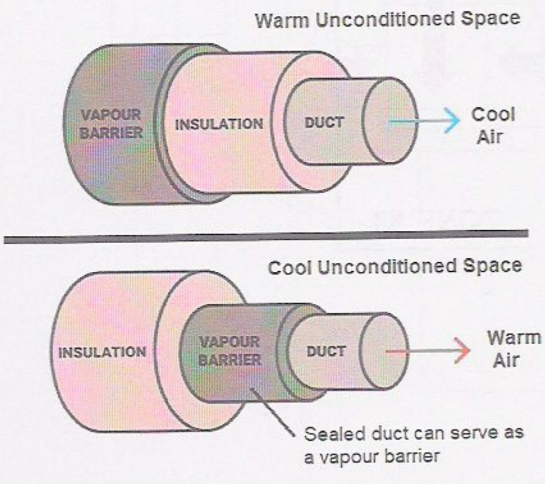



Figure 2.3

With a warm space an additional vapour barrier is required and must be sealed to prevent moisture from penetrating the insulation.

### *2.1.5 Metal Duct Wall Thickness*

The following chart is taken from the National Building Code (NBC).

| Minimum Metal Thickness of Ducts, mm (gauge) | | | | |
|---|---|---|---|---|
| Type of Duct | Maximum Diameter, mm (in) | Maximum Width or Depth, mm (in) | Galvanized Steel mm (gauge) | Aluminum mm (gauge) |
| Round | 350 (14) | - | 0.33 (29) | 0.30 (29) |
| | over 350 (14) | - | 0.41 (27) | 0.41 (26) |
| Rectangular, enclosed | - | 350 (14) | 0.33 (29) | 0.30 (29) |
| | - | over 350 (14) | 0.41 (27) | 0.41 (26) |
| Rectangular, not enclosed, with required clearances up to 12 mm (1/2 ) | - | 350 (14) | 0.33 (29) | 0.41 (26) |
| | - | over 350 (14) | 0.41 (27) | 0.48 (24) |
| Rectangular, not enclosed, with required clearances more than 12 mm (1/2 ) | - | 350 (14) | 0.41 (27) | 0.41 (26) |
| | - | over 350 (14) | 0.48 (25) | 0.48 (24) |

Figure 2.4

### *2.1.6 Combustion and Dilution Air*

It is important that the combustion and dilution air requirements of oil and gas fired heating equipment be satisfied. Such requirements can be found in the CSA and CGA Equipment Installation Codes B139 (oil) and B149 (gas) or applicable provincial codes. These requirements do not impact the air system design.

**Note:** See requirements in Section 2.3.2 governing the locations of Return Air Intakes.

# 2.2 Equipment Selection

The purpose of this section is to help the designer select the proper size and configuration of heating and cooling equipment.

Total Heat Loss and Total Heat Gain referred to in this section can be found

1. on page one, Section A, of the HRAI Residential Heat Loss and Heat Gain Calculations Worksheet.

**Note:** Within this section, limitations are applied to equipment selection. **These limitations are taken directly from the CSA F280 standard as referenced by the HRAI Digest.** For exceptions to these limitations, refer to the HRAI Residential Heat Loss and Heat Gain Calculation Manual or the CSA F280 Standard.

### *2.2.1 Gas, Oil, and Electric Furnaces*

To select the correct size of furnace or air handler:

From manufacturer's data, select a furnace or air handler with an output to at least meet the minimum heat loss requirements 100% of the Total Heat Loss (see Figure 2.5).

For electric furnaces, output and input are the same. For gas or oil furnaces, the output will be lower than the input, the difference being directly related to the efficiency of the furnace.

Example

House total heat loss = 50,000 Btuh

Minimum required output = 50,000 Btuh

Maximum output – no limit .

Figure 2.5

### *2.2.2 Cooling Unit*

To select the correct size of cooling unit:

From manufacturer's data, select a cooling unit with an output between 80% and 125% of that Total Heat Gain (see Figure 2.6).

If Heat Gain calculations were completed in watts, the watts can be converted to Btu/h by multiplying watts by 3.413.

Example

House total heat gain = 26,000 Btuh

Minimum required output = 26,000 x 0.8 = 20,800 Btuh

Maximum output = 26,000 x 1.25 = 32,500 Btuh.

Figure 2.6

### 2.2.3 *Air to Air Heat Pumps*

When selecting an air to air heat pump, the sizing issues become more complex, since it can be used for both heating and cooling. There are a number of different strategies available when it comes to sizing and selecting an air to air heat pump.

**#1 If a heat pump is to be used primarily for cooling and not so much for heating,** maximum cooling output of the heat pump found in the manufacturer's data should be between 80% and 125% of the Total Heat Gain.

If you are selecting a multi-stage or variable-capacity heat pump and are looking for a more balanced use of equipment in both cooling and heating, select a heat pump with a low stage cooling capacity that is in between 80% and 125% of the Total Heat Gain.

After a heat pump is selected based on its cooling output, since the same coils are used for cooling and heating, the heating output of the heat pump is now fixed and can be read from the manufacturer's specifications for different outdoor temperatures.

The heating output of the heat pump will normally be less than the Total Heat Loss. This is acceptable as the heat pump may not be in operation at design conditions and some source of supplemental heating (electric, gas, oil, etc.) will supply all or supplement most of the heating requirements. This supplemental heat shall have an output to meet the minimum requirements 100% Total Heat Loss.

A variation of this occurs when the heat pump operation is not restricted by a low temperature limit (heat pump operates regardless of outdoor temperature). In such applications, the heating output of the heat pump at design conditions plus the output of the supplementary heat must be a minimum of 100% of the Total Heat Loss.

These sizing methods are recommended to prevent excessive oversizing of the cooling unit which could cause a lack of humidity control and increased operating costs.

**#2 If a heat pump is to be used as a primary heating source**, the sizing criteria is as follows:

As the outdoor temperature becomes lower, the heat loss increases and the Coefficient of Performance (COP) for the heat pump decreases. If the heat pump were sized to meet the Total Heat Loss at design conditions, it would be grossly oversized for most of the year. Thus, the heat pump should be sized so that its heating capacity at 17°F ODT is close to estimated house heat loss at 17°F ODT.

To calculate an approximate heat loss at 17°F, take the Total Heat Loss and divide it by the Heat Loss ΔT found in the top left corner, page two, of the HRAI Residential Heat Loss and Heat Gain worksheet. This will give you an approximate heat loss for 1° of ΔT. By multiplying the same number by 55 (72°F - 17°F) you find the approximate Total Heat Loss at 17°F (see Figure 2.7). To select the correct size of heat pump, use the manufacturer's specifications to find a heat pump with a heating output greater than the approximate Total Heat Loss at 17°F ODT.

Example

Heat loss = 50,000 Btu/h
Outdoor design temp = 0°F

(1) Divide heat loss by ΔT
50,000 / 72 = 694.4 Btu/h/°F

(2) Find heat loss at 17°F ODT
694.4 x 55 = 38,192 Btu/h

(3) Select a heat pump which has a heating output of about 38,192 Btu/h at 17°F ODT.

Figure 2.7

The heating output of the heat pump at design conditions plus the output of the supplementary heat must be a minimum of 100% of the Total Heat Loss.

If the heat pump heating out at the design condition is not known (e.g. not published in manufacturer's extended performance tables or listed on third party validated tested data), the supplementary heat shall have an output no less than 100% of the Total Heat Loss.

**#3 If a heat pump is to be used as an only source of heating and cooling without supplementary heat**, the heating output of the heat pump at the design condition needs to meet 100% of the Total Heat Loss.

After selecting a heat pump based on its heating output, look up its cooling capacity and ensure that it is between 80% and 125% of the Total Heat Gain at any one of its operating stages.

This sizing strategy may be used when selecting a cold-climate heat pump which can provide considerable amount of heat efficiently even at low outdoor temperature.

### 2.2.4 Ground/Water Source Heat Pumps

The sizing of ground and water source heat pumps should be completed according to the heat pump manufacturer's instructions and CSA Standard C448.

Care should be taken to minimize the oversizing of equipment used for cooling.

The heating capacity of the heat pump needs to be sized to meet 65% to 105% of the design heat loss.

The total heating output of the heat pump and any supplementary heat should be no less than 100% of the Total Heat Loss.

### 2.2.5 Integrated Combo Systems

HRAI has published a "Unified Canadian Guideline for Integrated Combo Systems" which deals with all aspects of the sizing of both the water heater and air handler used for Combo units. For purposes of this manual, we only be concerned with the sizing of the air handler.

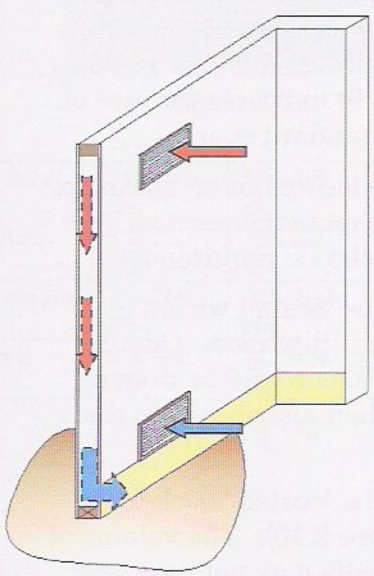
To determine the correct size of the air handler, select an air handler (from manufacturer's specifications) with an output between 110% and 140% of the Total Heat Loss, using a hot water temperature of 130 °F.

## 2.3 Return Air Inlets

### 2.3.1 General

A return air inlet should be positioned so that short circuiting of the supply air is avoided. As supply openings are near the exterior walls, it is recommended that return inlets be centrally located on and/or near interior walls.

It is generally accepted and recommended that floor and low wall return inlets are preferable for heating only systems and that ceiling or high wall return inlets are preferable for cooling only systems. The use of high/low wall returns (see Figure 2.8) for combined heating/cooling systems are ideal. If high/low wall return inlets are not used for combined heating/cooling systems, where possible, the system should include at least one high wall return inlet on the upper level of the home and a floor or low wall return inlet on the lower level of the home.



Low wall grill closed in summer

Figure 2.8

Although the building codes require a minimum of one return inlet per floor level in a house, it is generally accepted that by providing additional return inlets on larger floor levels:

- Cold drafts created by cooler air traveling across the floor to the return inlet(s) will decrease.
- The need for large door undercuts may be reduced or eliminated and air flow to the return inlets will not be restricted.
- Temperature differentials between different areas of the floor level tend to decrease.

As more return inlets are added, the cost of installing the duct system increases. Therefore, for each job, the designer must assess the number of return inlets based on both improved air flow and cost.

### 2.3.2 *Return Air Inlet Locations*

At least one centrally located return air inlet ***shall be*** provided in each floor level in a house including the basement.

| Door Undercuts | |
|---|---|
| Maximum airflow (cfm) | Minimum Door undercut inches |
| 30 | 1/2 |
| 60 | 3/4 |
| 90 | 1 |
| 120 | 1-1/4 |

Figure 2.9

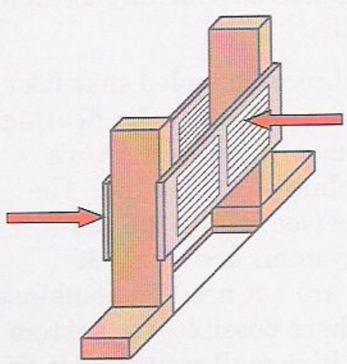


Figure 2.10

Return air inlets located in a finished basement or basement walkout ***shall be*** low wall.

Return air inlets ***shall be*** located in any room where at least 1/2 of the floor area is located over an unconditioned space (e.g. room over a garage).

Provision ***shall be*** made for the return of air from all rooms not having a return air inlet by undercutting doors, using louvered doors or installing door grilles. The chart at the left (Figure 2.9) indicates the size of door undercut required for a standard door.

Return air inlets ***shall not*** be located in an enclosure or crawl space that provides combustion air to a furnace or other appliance (fuel code requirement).

Return air inlets ***should not*** be located within a bathroom, kitchen, laundry or utility room. Odours and moisture from these locations would be drawn into the heating system and then distributed to the entire home.

Return air inlets ***should not*** be located "back to back" in a partition wall (Figure 2.10). The volume of air which the grilles could handle may not pass through the plate opening. Also the grilles will create

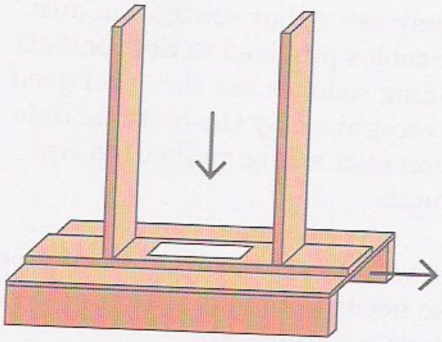


Figure 2.11

a passage for light and sound to travel between the two rooms.

Whenever possible, return air inlets ***should not*** be placed in walls which run parallel with the floor joist (Figure 2.11). In these cases, the plate opening is often restricted by the supporting floor joist and the joist space may not accommodate the air flow from the grille.

The duct system ***shall not*** create a negative pressure in the basement which might cause combustion products to spill or soil gases to enter into the basement. This can be achieved by sizing the basement return air intake(s) so that the total return air volume (CFM) from the basement is a maximum of 1/2 (50%) the total supply air volume (CFM) to the basement.

The return air inlet(s) on each level of a house other than the basement should be of suitable number and size to carry at least the total volume of air supplied to that level. It is recommended that any remaining return air volume (from basement) be returned from the uppermost level possible (see Figures 2.12/2.12a).

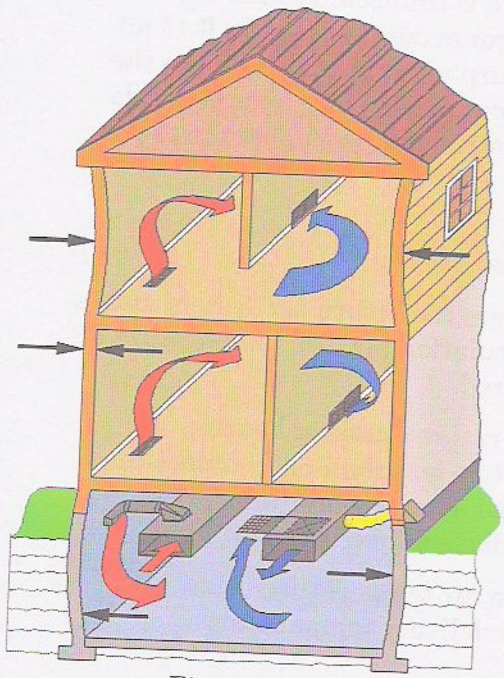


Figure 2.12

| | | | |
|---|---|---|---|
| 2nd floor | S/A 200 cfm | R/A 300 cfm | Negative pressure |
| 1st floor | S/A 250 cfm | R/A 250 cfm | Neutral pressure |
| Basement | S/A 200 cfm | R/A 100 cfm | Positive pressure |
| Totals | S/A 650 cfm | R/A 650 cfm | |

Figure 2.12a

### *2.3.3 Return Air Ducts*

A vertical return air duct ***shall not*** have return inlets on more than one floor. This is to stop cool air from siphoning from one floor to another and to provide adequate fire stopping.

Return ducts serving a solid fuel fired furnace ***shall be*** constructed of non-combustible materials.

Spaces between studs used as return ducts ***shall be*** separated from unused portions of such spaces by tight-fitting metal stops, wood blocks or other approved materials.

### *2.3.4 Ventilation Air Duct Connected to a Return Duct*

When an outdoor air intake is directly connected to a return trunk duct (Figure 2.13) or an outdoor intake from another ventilation equipment (e.g. HRV) is connected to a return trunk duct (Figure 2.14), the intake duct shall be sized using the acceptable ventilation duct sizing methods as recognized by the building code.

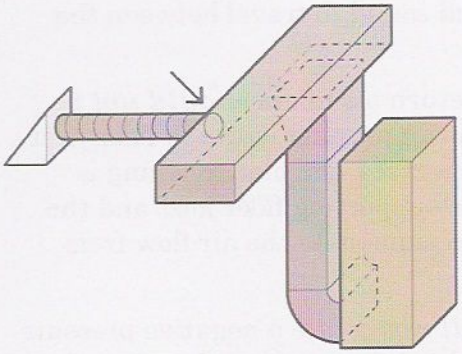


Figure 2.13

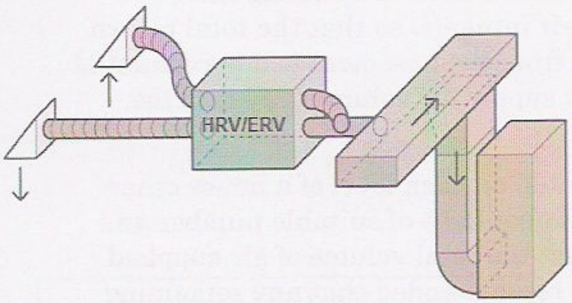



Figure 2.14

For this, a designer may use either ventilation duct sizing instructions or tables provided in Section 9.32 of the applicable building code, or use the other good engineering practice recognized by the building code (e.g. HRAI's ventilation duct sizing method) to size the outdoor intake ducts.

In addition, the location of the outdoor air connection to the trunk duct also needs to comply with applicable building code requirements.

- NBC (National Building Code) requires that when an outdoor air intake is connected to the return duct, it needs to be connected at least 10 ft (3 m) upstream of the return plenum connection to the heating unit or be connected using an acceptable mixing device as described in the appendix to the NBC.

**Mixed Air Temperatures**

When outdoor air enters the return air system and is mixed with the re-circulation air, the temperature of the return air is lowered.

The return air temperature entering heating equipment should not be less than 60°F unless the manufacturer specifies a lower limit (see manufacturer's installation instructions).

**Note:** Using a return air temperature below 60°F may result in low air delivery temperature

**Calculation of Mixed Air Temperature:**

The mixed air temperature can be determined using the following three steps (see example Figure 2.15).

1. Using the outdoor air cfm (from the ventilation system design), and the return air cfm, which is the same as the heating air flow rate from section B.4 of the HRAI Worksheet for Residential Air System Design, find the percent house air from the Percent House Air chart in Appendix C (C9a).
2. If heat recovery equipment (HRV, ERV) is used the designer needs to find the temperature of the air delivered from the heat recovery equipment in order to complete # 3 below. Using the winter outdoor design temperature from the heat

Example

Outdoor design temp = - 8°F
Return air cfm = 800 cfm
Outdoor air cfm = 120 cfm
HRV effectiveness = 75%

1 Percent house air from C9a
Using 800 and 120 = 85%

2 HRV delivery temperature from
C9b, using -8°F and 75% = 49°F

3 Mixed air temperature from C9c,
using 85% and 49°F = 65°F

Figure 2.15

loss/gain calculations and the HRV effectiveness at the winter outdoor design temperature (ODT), find the HRV air delivery temperature from the HRV Air Delivery Temperature chart in Appendix C (C9b) of this manual.

If an HRV/ERV is not used, air delivery temperature equals ODT.

3. Using the Percent house air from step 1 and the winter ODT from the heat loss/gain calculations or the HRV air delivery temperature (whichever is applicable), find the mixed air temperature of the return air entering the furnace from the chart in Appendix C (C9c) of this manual.

If the mixed air temperature is too low it can be increased by:

- increasing the heating air flow rate
- preheating the fresh air using a heat recovery unit such as an HRV/ERV
- preheating the fresh air with a duct heater. This would require a control system to prevent the heater from operating:
  1. when outdoor air temperature is high enough that mixed air temperature without preheat would be above 60° F.
  2. when there is no air flowing through the heater.

**Note:** If continuous fan flow rate is different than heating flow rate, the mixed air temperature should be checked at both conditions.

**Note:** For more information regarding ventilation and ventilation systems, refer to the HRAI Residential Mechanical Ventilation manual.

### *2.3.5 Conversion of Gravity to Forced Air*

When converting a gravity system to a forced air system, it is usually possible to use the existing centrally located supply air stacks to the second floor for the return ducting from the second floor. If this is done, the dampers in the existing supply registers should be removed or fixed open and the stack duct should be cleaned. If the existing first floor registers were supplied through the same vertical riser as the second floor diffusers, the first floor openings should be closed off.

For the first floor, use either one or more of the existing gravity supply outlets as return inlets, or install a new inlet(s) in more suitable locations.

In existing homes, where it is not practical to draw return air directly from the upper floor(s), upper floors return air may be returned to a centrally located inlet near the base of the stair at the 1st floor level provided the inlet is properly sized and is open to the upper levels.

If the second floor rooms are isolated from the ground floor by means of a door at the base of the stairs, then a suitable return inlet should be installed in the floor or wall on the stairway side of the door. This inlet shall be of sufficient capacity to handle the return air requirement of the second floor rooms.

**Note:** If upper floor return air volume is drawn through openings on the first floor, drafts may be created on the stairway between floors. Warm air at the ceiling of the upper floors will not be removed during the cooling season.

# 2.4 Supply Air Outlets

## *2.4.1 General*

While it is recognized that high wall or ceiling diffusers are desirable for cooling, it is also recognized that the floor perimeter diffuser location provides satisfactory winter performance for heating only systems. Supply outlets shall be located as to bathe at least one exposed wall or window with warm air, as shown in Figure 2.16.

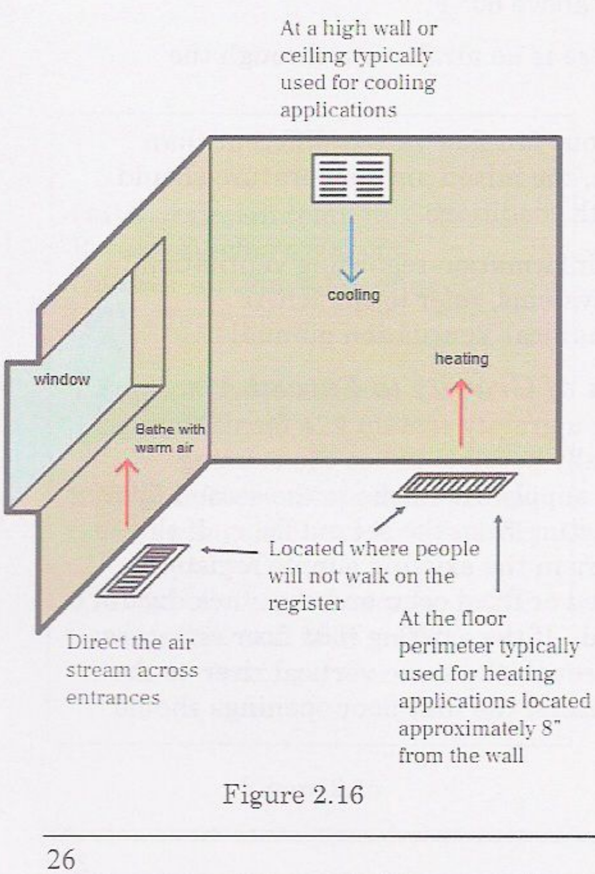



Figure 2.16

The number and placement of supply outlets in a room may depend on the amount of heat required and the number and size of the exposed walls. The intent is to bathe one or more of the exposed wall(s) with warm air.

To determine the minimum number of outlets required to deliver the required amount of heat, refer to Figure 2.17. This chart gives the maximum recommended heat delivery for a single outlet in relation to the temperature rise over the heat exchanger.

To determine the minimum number of outlets required to adequately blanket the exposed wall(s),

| Temp Rise over Heat Exchanger (°F) | Maximum Delivery per Outlet (Btu/h) |
|---|---|
| 90 | 8,000 |
| 80 | 7,000 |
| 70 | 6,000 |
| 60 | 5,000 |
| 50 | 4,000 |
| 40 | 2,500 |

Figure 2.17

compare the spread and throw of the diffuser at 500 FPM with the length of exposed wall. It is not necessary that all wall areas be covered by the spread and throw of the diffuser(s). It is normally accepted that an average size room with two exposed walls, will have one or two diffusers and a room with three exposed walls will have two or three diffusers. These numbers may vary depending on the size of the room, window size and heat loss/gain of the room. Where a single diffuser is used in a room with two exposed walls, the diffuser should bathe the wall having the greater heat loss/gain.

### 2.4.2 *Supply Air Outlet Location*

At least one supply outlet ***shall be*** provided in each finished room which is located adjacent to an unheated space.

All outlet(s), for heating/cooling systems, ***where possible, shall be*** perimeter outlets located so that the introduced air will bathe at least one exterior wall. Bathroom, kitchen and utility room outlets are exempt where a perimeter outlet location is not practical.

Horizontal discharge outlets ***shall not*** be located on exterior walls.

A supply air outlet ***shall not*** be installed on a furnace plenum or trunk duct.

The temperature of air at the supply air outlet ***shall not*** exceed 70° C (158° F).

All supply outlets located in finished areas ***shall be*** provided with a diffuser.

All supply branch ducts which are not fitted with diffusers which have an adjustable balance stop ***shall be*** supplied with an adjustable damper and fitted with a device to indicate the position of the damper.

Floor outlets should be located far enough from the inside surface of the outside wall to avoid interference with draperies (typically 8" from the wall). An example would be a living room window or a patio glass door where draperies or blinds may be installed.

For front entries where a floor outlet is used, avoid placing the outlet where it will be walked on. A low wall or baseboard outlet may be installed in an adjacent partition with the air stream directed across or toward the entry door.

Side and/or rear entries may be heated by virtue of the heated basement air if the entry is open to the basement.

Any walk-in closet with a heat loss exceeding 1000 Btu/h ***should have*** a separate supply outlet. If the heat loss of a walk-in closet is less than 1000 Btu/h and no separate supply outlet is provided, the heat loss ***shall be*** added to the loss of the adjacent room for the purpose of sizing that room's supply duct. It is recommended that, in such cases, a return air inlet may be located within the walk-in closet to create some circulation within the closet.

In crawl spaces, sufficient outlets ***shall be*** installed to compensate for the heat loss and they should be located to give maximum heat distribution. These outlets shall be equipped with a diffuser or a lockable damper.

When the duct system or portion of a duct system is to be an "in slab system" (e.g. slab on grade house construction) the duct design and installation should follow the methods described in Appendix D of this manual.

For unfinished basements, at least one supply outlet shall be supplied for each 40 m² (430 ft²) of floor area. These outlets shall be located to provide adequate distribution of warm air, and ***shall be*** provided with a diffuser. These outlets may be located at the ceiling level.

For purposes of the design and installation of air distribution systems, all finished basement rooms and basement rooms with "walk-outs", ***shall comply*** with the following requirements for "Habitable Basement".

### *2.4.3 Habitable Basement*

Residential buildings having basement rooms that are finished so as to be a habitable space and/or whose floor is at or near grade level (walk-out basement), ***shall be*** heated by one of the following three methods:

1) Thermostatically controlled supplementary heat with a total heat output sufficient to provide at least 20% of the heat loss of the space, to be used in conjunction with the main residential warm air heating system. In such applications, the supply outlets may be located at the ceiling level and shall be sized to deliver 100% of the heat load of the basement.

2) A separate system or zone of a system which is controlled by its own thermostat (located in that part of the finished basement) and capable of delivering 100% of the heat load of the basement. Supply outlets should be at or near floor level.

3) Where habitable basements are fully insulated (insulation full height of exposed walls), supply outlets will be located at exterior walls or in that part of an adjacent partition wall which is close to the exterior wall. Outlets shall be within 6" of the basement floor. The circulation (furnace) fan which provides the main air movement in this area shall be set to run continuously.

**Note:** For all three methods outlined above, the return air openings shall be at or near floor level.

It is possible that local building codes may also recognize other acceptable approaches of supplying warm air to a habitable basement.

If this is the case, designers can choose follow the habitable basement heating methods as accepted by building code even if it does not meet HRAI's good engineering practice.

Figure 2.18

### *2.4.4 Conversion of Gravity to Forced Air*

**Upper Floor**

Whenever possible, it is desirable to install a perimeter supply system. However, it is not an uncommon practice to re-use many of the existing upper floor supply stacks to reduce cost and disruption. In such cases, each room of the upper floor should have its own individual supply stack and outlet. Double register boxes connected to a single stack are not suitable for forced air use. In cases where an existing stack terminates in a double register box, one of the outlets should be blanked off. A new warm air stack and outlet should be provided for the blanked off area.

All new outlets should employ forced air type registers or perimeter diffusers. All existing gravity type registers should be replaced by forced air type registers with downward deflection.

In some cases, it may be impractical to install individual stacks passing through the ground floor to serve the upper floor rooms. In such cases, it may be possible to install a single trunk duct through a ground floor closet or corner and similarly through the second floor to the attic (Figure 2.19). The distribution system can then be installed in the attic with a short stack downward to the high side wall or ceiling of each upper floor room.

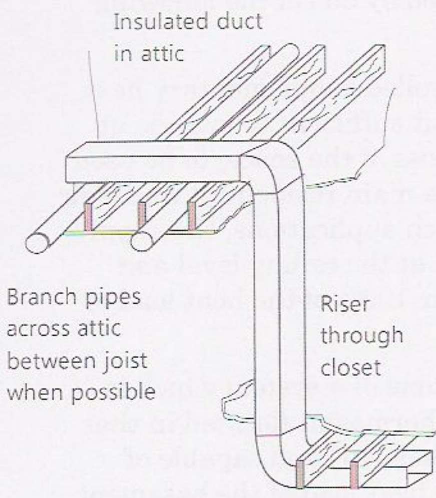



Figure 2.19

All supply and return ducts passing through unheated spaces ***shall be*** insulated to an R-value equal to that required by applicable codes for the adjacent wall, or ceiling structure.

### Ground Floor

Existing gravity registers located on interior walls should not be used for warm air outlets. An exception to this is in rooms such as bathrooms and kitchens where it may be impractical to use perimeter diffusers, due to the location of fixtures. In such cases, any existing open-faced gravity-type registers should be replaced by bar faced registers with downward air deflection.

Install Perimeter diffusers in all other ground floor rooms.

## *2.4.5 Flex Duct*

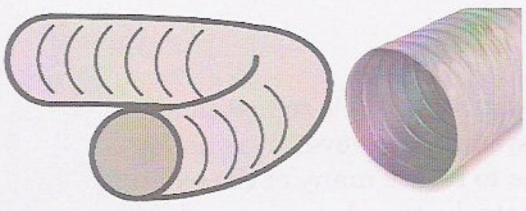


Figure 2.20

The use of flexible ducts (Figure 2.20) as branch ducts, in residential systems is growing more popular. Flexible ducts facilitate installation in restricted work areas and insulated flex ducts provide noise attenuation (dampening) and freedom from condensation. To prevent frost build-up, ducts with insulation and an outside vapour barrier must be used to carry outside air into a house for either combustion air or ventilation air.

### Equivalent Length for Flex Ducts

Flexible ducts, used in conjunction with this manual, shall be given an equivalent length of two feet for every foot of linear length. Elbows and other fittings made with flexible ducting shall have an equivalent length of double that of a similar fitting.

# 2.5 Air Duct Leakage

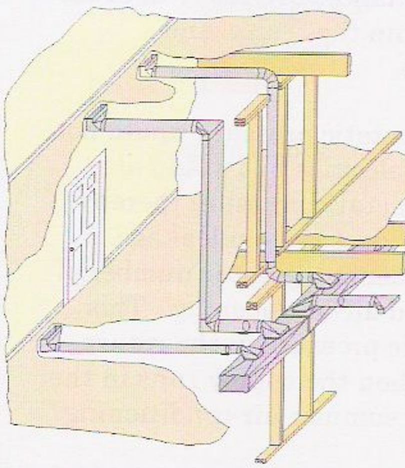


Figure 2.21

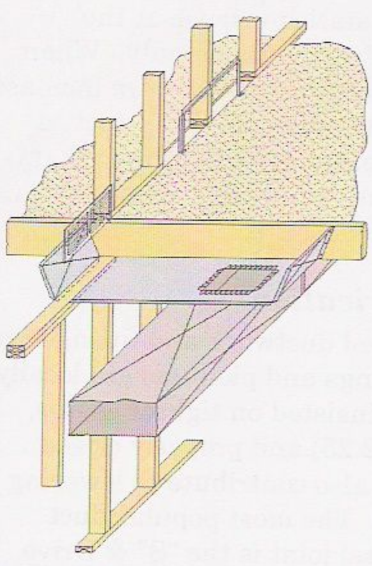


Figure 2.22

Air duct leakage may be considered part of air duct integrity. While the duct strength is controlled by gauge and material (see building code table), rigidity is controlled by cross-breaking or beading, thermal expansion is controlled by duct hangers that allow movement, noise transmission is controlled by duct lining, vibration is controlled by flexible connectors, and heat gain and loss are controlled by external insulation (duct wrap). The one aspect of duct integrity that is inadequately controlled, particularly in residential systems, is air duct leakage.

In some cases, it is reported that up to 40% of air leaks from air ducts, and while the acceptable leakage limit is generally 5%-10%, system efficiency today is in much greater demand and therefore duct leakage must be reduced even further.

It must also be understood that duct leakage is not uniform throughout the system. It could in some branches (second floor risers) (Figure 2.21) be 20% or more and in some main floor branches be only 5%. This type of variation seriously affects air distribution and therefore the heating and cooling temperatures throughout the home would also vary causing serious discomfort to the occupants. Return air ducts (Figure 2.22) that utilize joist space cavities are likely to be the part of the system with the greatest amount of leakage. This generally occurs within the confines of the basement. Although there is an attempt to reduce negative pressure within this area, the use of leaky joist space cavities for return air branches will generally negate this attempt.

Air duct leakage can be broken down into several areas of concern and include; system design static pressure, duct system fabrication, and duct system assembly and installation.

### *2.5.1 System Design Static Pressure*

Many appliances/furnaces today have static pressure capabilities far beyond that required for air duct systems and their accessories. Designers must accurately estimate only the required static pressure for any given job. An assessment of sufficient design static pressure could be seen as a system in which the

system velocities fall within the recommended range as indicated by the chart of "Recommended Design Velocities"

Designers should pay particular attention when analyzing the distribution system. Systems where balancing dampers (Figure 2.23) are used to correct serious branch airflow imbalances are likely to cause higher static pressures within the trunk, and therefore increased leakage.

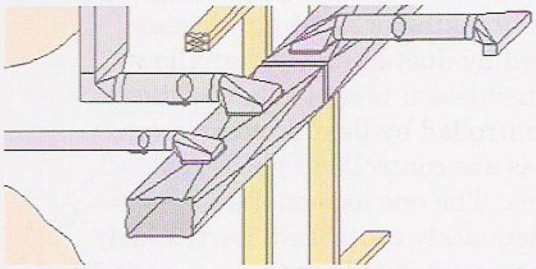


Figure 2.23

The use of excessive design static pressure would not only produce high system velocities but would also produce higher duct system static pressure thereby increasing the possibility of duct system leakage. Designers should consider using a greater number of plate openings with reduced airflow/opening. This would help reduce the static pressure in the return air system, in particular when the supply runs in the basement are closed off for summer air-conditioning.

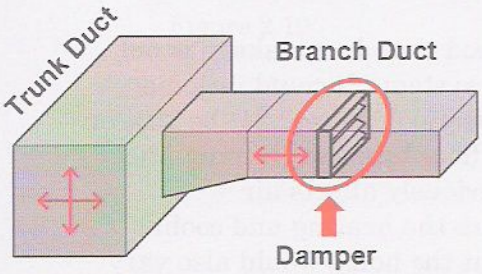
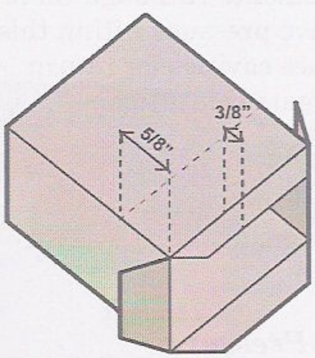



Figure 2.24

Volume and Zone type dampers (Figure 2.24) could also be the cause of higher static pressures in both trunks and branches, in the case of branch dampers normally located at the register boot (because of convenience). If they were relocated to the correct position at the point of take-off, this would then eliminate any increase in static pressure at the branch run and transfer it to the trunk only. When activated zone dampers can produce a severe increase in static pressure in almost any part of the duct system. It then becomes extremely important that fan/motor control be sensitive to higher pressures and ramp down accordingly.

### 1.5.2 *Duct System Fabrication*

While much of the installed ductwork and fittings are pre-fabricated, many fittings and plenums are locally produced. If contractors insisted on tighter seams, careful notching (Figure 2.25) and properly closed corner seams, this would also contribute to lowering the air duct leakage rate. The most popular duct assembly transverse (cross) joint is the "S" & Drive. In some instances "S" cleats are cut as much as 1" shorter than the duct width. This practice again will contribute to air duct leakage at the corners of joints, cutting "S" cleats 3/8" shorter than the duct width is sufficient to facilitate assembly.




Proper notching of duct and fittings includes a 1" straight notch and a 3/8" clip. This should ensure minimum leakage at the corners.

Figure 2.25

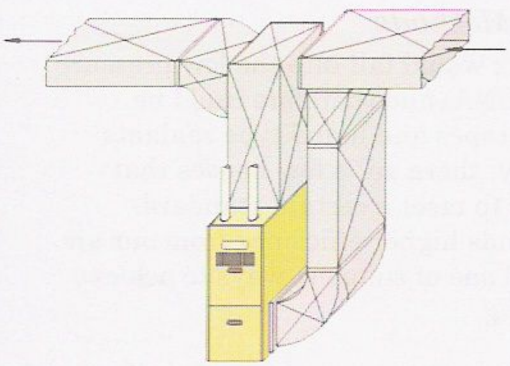


Figure 2.26

### 2.5.3 Duct System Assembly and Installation

Typically, most installations begin with attaching fittings to the equipment (Figure 2.26), then the main trunk ducts and finally branch runs. Much of the leakage that occurs is due to sloppy joint assembly, cutting-in of take-offs and starter collars. It has also become common practice in some areas to place 5" and 6" diameter risers inside 2" x 4" cavity walls (Figure 2.27). If the walls were furred out to 2" x 6" cavity walls, then this practice would be acceptable. Unfortunately in some cases, these duct risers are being installed in 2" x 4" cavity walls without being furred out. This practice is not **"good engineering practice"** and is absolutely unacceptable. Not only does this practice reduce the capacity of the duct risers, it also increases the rate of friction and most likely would open up both vertical (transverse) and horizontal (longitudinal) seams when being squashed into place. See following calculations:

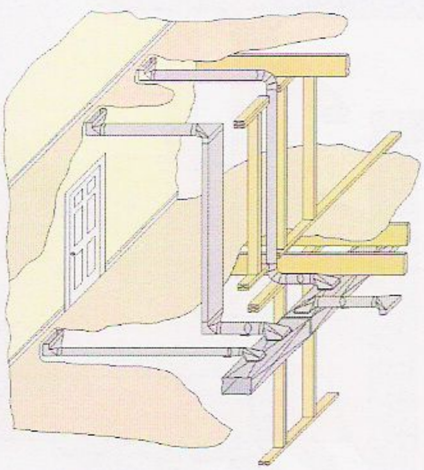
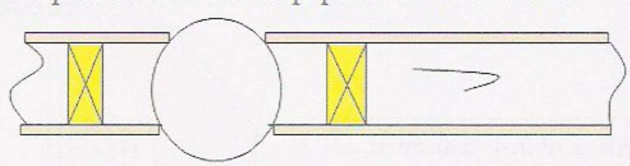


Figure 2.27

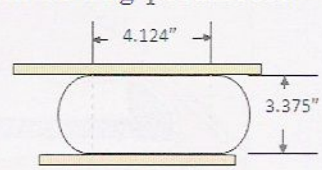
Perfect ovalization of round ducts

Example: 6" diameter pipe in 2" x 4" wall.



- Perimeter = 3.142 x diameter = "18.852"
- Area = 3.142 x $r^2$ = 28.278 sq/ins

Maintaining perimeter = 18.852"




Area of oval = ($\pi$ x $r^2$) + (4.124 x 3.375) = 22.866 sq/ins

Convert to diameter = dia = $\sqrt{\frac{22.866}{3.142}}$ x 2 = 5.4" dia

### 2.5.4 Duct Sealing Methods

Figure 2.28

Residential ductwork would fall into the low pressure classification (SMACNA) and therefore could be sealed with various tapes and liquid type sealants (Figure 2.28). Today, there are a few houses that require duct sealing to meet a certain standard. Industry now demands higher efficiency from our air moving systems and one of simplest ways to achieve this is by duct sealing.

At this point in time there are no written Canadian "Residential Duct Construction and Installation Standards" but HRAI feels that including this section (Air Duct Leakage) is a start in providing some guidance towards systems that are more air tight and efficient.

Regardless of any standard, all ducts that are concealed within a chase (Figure 2.29), wall or cavity should be sealed with duct tape or low velocity duct sealer.

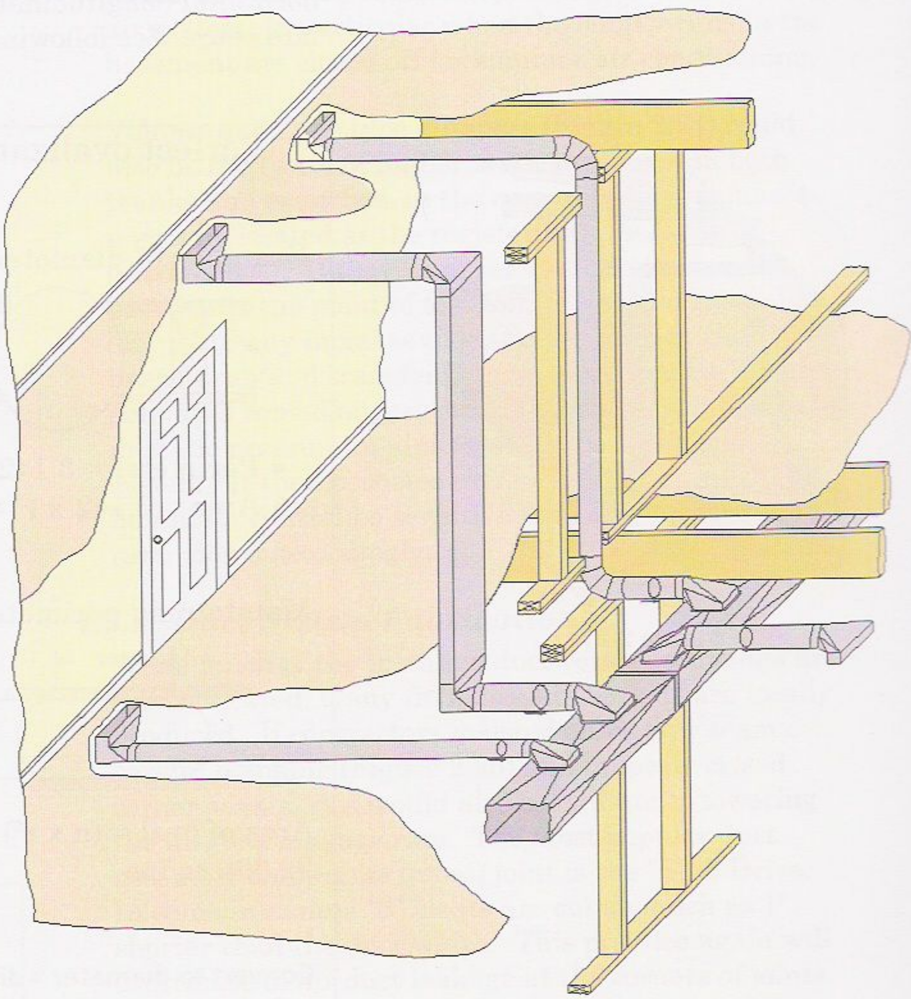


Figure 2.29

# 3 AIR SYSTEM DESIGN PROCEDURE

This section of the manual should be used in conjunction with the HRAI Worksheet for Residential Air System Design. The headings in this section follow the same order as the headings on the worksheets and the text of this section explains how to fill in the worksheets.

Where this section requires information regarding heat loss/gain calculations, the heat loss/gain information should be taken from the HRAI Residential Heat Loss and Heat Gain Calculations worksheets.

## 3.1 Worksheet for Residential Air System Design (page 1)

Page one of the Worksheet for Residential Air System Design is used to record all the preliminary data including: inspection authority, Designers signature, building owner and address, contractor details and a list of proposed equipment at the time of design. There is a space at the top right for a copy of the designer's HRAI wallet card with certification #. At the bottom of page one right side, there is a place to record the mixed air temperature as determined using Appendix C (C9a, C9b, C9c). This is only required when the ventilation system is integrated with the air system for the house.

**Note:** Mixed air Temperature can only be determined after the Heating CFM (worksheet B.4) has been chosen.

# 3.2 Part A Design Load Specifications (page 2)

### *A.1 Sub Total Heat Loss*

From the heat loss /gain calculation, enter the sub total heat loss of the building which is heated by utilizing the forced air heating system. Do not include rooms that are heated exclusively using their own independent heat source, such as electric baseboard heaters.

### *A.2 Ventilation Heat Loss*

From the heat loss /gain calculation, enter the heat loss due to ventilation. Ventilation refers to outside air that is introduced mechanically into the house. Systems that bring outside air into the building and directly into the duct system (integrated systems) will require a mixed air temperature calculation which is recorded on page one. For information on mixed air temperature calculations, see "mixed air temperatures" in section 2.3.4 of this manual .

### *A.3 Total Heat Loss*

This is the sum of the sub total heat loss and ventilation heat loss (A.1 + A.2). This total represents the entire heat loss of the house and is used to determine the output of the heating equipment. No reduction is made for recovered heat from ventilation equipment.

### *A.4 Sub Total Heat Gain*

From the heat loss /gain calculation, enter the sub total heat gain. This total would represent the portion of the house that is conditioned in the summer, using the forced air system and must include only areas which are calculated as part of the sub total heat loss in A.1. If for some reason cooling is not required (summer ODT below 82°F), then this line may be left blank.

### *A.5 Ventilation Heat Gain*

From the heat loss/gain calculation, enter the heat gain due to ventilation. This represents both sensible and latent heat gains due to mechanical ventilation.

### *A.6 Total Heat Gain*

This is the sum of the sub total heat gain and ventilation heat gain (A.4 + A.5). This total represents the entire heat gain of the house and is

used to determine the output of the cooling equipment.

### *A.7 Volume of House*

From the heat loss/gain calculation, determine the heated area (sq. ft.). This heated area, when multiplied by the average ceiling height, will produce the internal volume of the house. This would include all conditioned spaces including the basement.

volume of house = heated area x average ceiling height

### *A.8 Ventilation Flow Rate*

When the ventilation system is integrated (connected) to the return air duct system, both the volume and physical connection of the ventilation system will affect the design of the main return air duct system. If the design does include an integrated system, then, from the heat loss/gain calculation, enter the Principal Ventilation Capacity (PVC). For designs that are not integrated, this line will be left blank. See Heat Loss/Gain worksheet for PVC.

## 3.3 Part B Equipment Selection

Appendix A of this manual contains example specifications. For actual field designs, use equipment specifications provided by the equipment manufacturer.

### *Heating Equipment*

From the heating equipment manufacturer's specifications, record the make, model # and fuel type of the selected equipment.

### *B.1 Heating Output*

From the heating equipment manufacturer's specifications sheets, record the Btu/h output. The output shall be at least 100% of the Total Heat Loss (A.3). See HRAI Residential Heat Loss and Heat Gain Calculations manual for exceptions.

### *B.2 Approved Temperature Rise/Range*

From the heating equipment manufacturer's specifications sheets, record the approved temperature rise or range. All manufacturers provide a temperature rise/range at which the equipment operates both safely and efficiently.

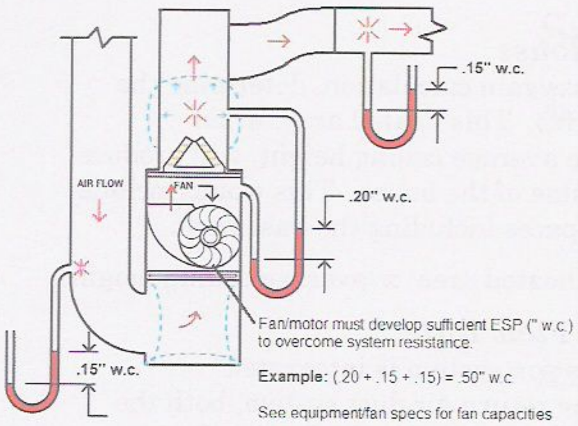



Figure 3.1

### *B.3 Equipment External Static Pressure*

From the heating equipment manufacturer's specifications sheets, record an external static pressure suited to the operating pressure requirements of the system. This external (operating) pressure is the sum of all pressure drops (resistances) including duct systems, coils, and other accessories such as filters. For areas where the summer outside design temperature is 82°F or greater, the design of the cooling system is mandatory. If this is the case, an external static pressure of 0.5 in. W.C. or greater should be used (see Figure 3.1). For systems where heating only is required and no cooling evaporator coil is present, a more suitable external static pressure would be 0.25 in. W.C. or greater.

**Note:** Equipment external static pressure requirements may vary subject to the differences in the pressure drop of system accessories such as coils, filters and duct systems. Selecting higher external static pressures may result in velocities which exceed the recommended limits. For an average duct system, an external static pressure of 0.25-0.30 in. W.C. (after accessory pressure drops are subtracted from the equipment ESP) should suffice, (see Figure 3.1). Longer duct systems may require a higher pressure.

**Note:** Some Equipment manufacturers offer external static pressures in excess of what may be required to operate the HVAC system. In this case the designer will have to estimate the duct system operating pressure and size the HVAC system at the estimated pressure plus any system accessories (see Figure 3.1a).

Example:

Equipment manufacturer's maximum external static pressure
= 0.80" W.C.

Evaporator coil pressure drop
= 0.23" W.C.

Resulting duct system pressure
= 0.80"W.C. – 0.23"W.C.
= 0.57"W.C.

If the designer were to use the 0.57"W.C. for the duct system it would most likely result in excessive trunk duct velocities. In this case the designer may estimate the duct system pressure i.e. 0.30"W.C. and add it to the coil pressure drop. This would then result in a system design external static pressure of only 0.53"W.C. The designer would then select a fan cfm at this external static pressure, or in the case of an ECM motor the speed/cfm would be controlled at the original cfm/speed setting.

Figure 3.1a

### *B.4 Heating Air Flow Rate*

From the heating equipment manufacturer's specifications and fan performance charts, determine the manufacturer's heating fan speed or rpm and air volume (cfm) at the selected external static pressure (B.3). The selection method will vary depending on the information given by the manufacturer. If the heating equipment is operating with a single temperature rise (older heating equipment); the following formula may be used to determine the airflow delivery:

**cfm = [ B.1 ÷ (1.08 × B.2) ]**

*Note:* This formula is most useful when evaluating older systems and where operating cfm is not known.

### *Cooling Equipment*

From the cooling equipment manufacturers specifications sheets, record the make, model # and cooling medium of the selected equipment.

### *B.5 Cooling Output*

From the cooling equipment manufacturer's specifications sheets, record the output capacity (Btu/h). This capacity shall be at least 80% and no more than 125% of the Total Heat Gain (A.6). See HRAI Residential Heat Loss and Heat Gain Calculations manual for exceptions. This output capacity is then converted to nominal tons, as indicated by the manufacturer. This number of tons will be used to determine the required air flow for the cooling equipment. (12,000 Btu/h = 1 Ton)

### *B.6 Manufacturers Flow Rate/Ton*

From the cooling equipment manufacturer's specifications sheets, record the required flow rate per ton of cooling. This air flow rate (usually 400 cfm/ton) is established by the manufacturer, which helps ensure that icing of the evaporator coil does not occur and also that the correct amounts of both latent and sensible heat are simultaneously removed from the passing air flow.

| Summer Mean Daily Temp Range | | Cfm/ton |
|---|---|---|
| Low | (0°F to 15°F) | 300 |
| Medium | (16°F to 25°F) | 360 |
| High | (26°F and above) | 420 |

Figure 3.2

If the manufacturer's specifications do not provide the air flow rate per ton, the Air Conditioning, Refrigeration Institute (ARI) recommends the table shown in Figure 3.2 may be used to establish the **minimum** air flow requirements.

### *B.7 Cooling Air Flow Rate*

From the cooling equipment manufacturer's specifications sheets and fan performance charts, determine the manufacturer's cooling fan speed or rpm and air volume (cfm) at the selected external static pressure (B.3). In many cases, the manufacturer's cooling speed or rpm is set for the greatest number of tons the equipment can handle. If the related cfm proves to be too great for the number of tons required, select a lower rpm or speed at the selected external static pressure that provides an adequate air volume for the number of tons in the design.

**Note:** The following formula may be used as a guide to establish the approximate/Target cfm requirements when selecting the speed/rpm from the manufacturer's fan tables. **(B.5 (tons) x B.6)**

### *B.8 Coil Pressure Drop*

From the cooling equipment manufacturer's specifications sheets, record the expected evaporator coil air flow pressure drop. This pressure drop (in. W.C). is given by the manufacturer for both dry and wet conditions at various flow rates. The pressure drop recorded must be the greater of the coil in its wet condition at the cooling flow rate and its dry condition at the heating flow rate. This ensures, under the worst conditions that sufficient allowance for the coil pressure drop has been provided. There is a wide variance in pressure drop amongst the coils presently available, and therefore, the coil used can have a very significant impact when determining the equipment (system) external static pressure.

## 3.4 Part C Air Distribution and Pressure

### *C.1 Circulation Air Flow Rate*

Using the formula (A.7 x .025), calculate and record the circulation air flow rate (cfm) that provides a complete house volume re-circulation of 1.5 (min) to 2.5 (max) changes per hour. This re-circulation ensures the forced air system provides sufficient air movement within the house to prevent air stratification and therefore improves occupant comfort (good engineering practice).

**cfm = A.7 x .025**

Where: - cfm is the minimum air flow rate for circulation

- A.7 is the volume of the house

- 0.025 is the air changes (1.5) divided by the time (60 minutes)

**Note:** The circulation flow rate is considered a system check to ensure good circulation is provided by the operating fan speeds. It is not normally expected that an additional fan speed setting is required to produce this.

### *C.2 System Design Air Flow Rate*

Record the highest volume (cfm) of B.4, B.7 or C.1. This air volume will be the minimum system design air flow rate and will satisfy the air flow conditions for heating, cooling and provide at least the minimum 1.5 re-circulation rate.

### *C.3 Cooling Air Flow Proportioning Factor*

Using the formula **(B.7 ÷ A.4)**, calculate and record the cooling air flow proportioning factor. The proportioning (or distribution) factor is a value showing a ratio of the amount of cfm required to deliver a single Btu/h of cooling at the cooling air flow rate. Therefore, when this number is known, the total cfm per room can be determined. This proportioning factor is used to determine the room cfm requirements for cooling only systems and is considered optional for combined heating and cooling systems.

**Note:** To maintain reasonable accuracy, this calculation must be performed to **4 decimal places.**

### *C.4 Heating Air Flow Proportioning Factor*

Using the formula **(C.2 ÷ A.1) or (B.4 ÷ A.1)**, calculate and record the heating air flow proportioning factor. This proportioning (or distribution) factor is a ratio showing the amount of cfm required to deliver a single Btu/h of heating at the system or heating design speed. Therefore, when this number is known, the total cfm per room can be determined. This proportioning factor is used to determine the room cfm requirements for heating only systems and heating/cooling systems. When a system is designed for both heating and cooling room loads, it is recommended that branch runs be sized to accommodate the larger of either the room cooling or room heating cfm. This practice should ensure velocities are not beyond their limits if the fan speed changes with the heating and cooling seasons. Also, the duct system branch runs must have the ability to be balanced with each change in season.

### *C.5 Calculated Heating Temperature Rise*

Using the formula **[B.1 ÷ (B.4 x 1.08)]**, calculate and record the actual operating temperature rise of the heating equipment. This temperature rise, when calculated, must be checked and be within the heating equipment manufacturer's temperature rise limitations. The temperature rise limitations are to

ensure the equipment operates both safely and efficiently.

**Note:** Failure to comply with temperature rise limitations may result in damage to the heating equipment and thereby void the manufacturer's warranty.

### *C.6 Filter Pressure Drop*

When the heating equipment standard filter is to be removed and replaced with a filter having a different pressure drop, subtract the standard filter pressure drop (in. W.C.) at the highest air flow conditions (C.2) from the pressure drop of the replacement filter (also at the highest air flow conditions) and record the difference.

**Note:** When filters or other accessories i.e. coils are added to the system, they often result in increased operating pressure requirements. A failure to account for these additional pressure requirements could result in reduced system airflow.

### *C.7 Coil Pressure Drop*

Record the cooling coil pressure drop from line B.8.

### *C.8 Total Pressure Drop*

Using the formula **(C.6 + C.7)**, calculate and record the total pressure drop. This pressure drop must be the sum of all resistances caused by the addition of coils, filters and any other plenum or trunk duct supplementary equipment.

### *C.9 Available Design Pressure*

Using the formula **(B.3 - C.8)**, calculate and record the available design pressure. The available design pressure will be used to overcome the resistances of both supply and return duct systems. This would also include accessories such as grilles and diffusers. The pressure requirements for duct systems may vary considerably according to their size and complexity.

**Note:** Higher duct design pressures may cause branch and trunk duct velocities to exceed their normal limits and produce excessive noise and draft. For an average length of duct system, a pressure of 0.25 - 0.3 in. W.C. (after accessory pressure drops are subtracted from the equipment ESP) should suffice. Longer duct systems may require a higher pressure.

# 3.5 Part D

# Determining Room and Floor Design Flow Rates (page 3)

### *D.1 Floor*

Record the name of the floor level, then count the number of rooms (one column per room) for each floor level and section off D.1 vertically to separate the different floor levels.

### *D.2 Room*

Record the name of each room in which either cooling air flow, heating air flow or both are to be delivered.

### *D.3 Cooling Load (Btu/h)*

Record the cooling load (heat gain) for each room. These loads are found in the heat loss/gain calculations.

**Note:** If the room cooling loads are not considered, this line will be left blank.

### *D.4 Room Cooling Flow Rate*

Using the formula **(D.3 x C.3)**, calculate and record the room flow rate (cfm). This calculation is used to determine room flow rates for summer cooling and is considered optional for systems where the room cfm for summer cooling loads exceed the cfm for winter heating loads. This option may be exercised when the desire for greater degree of summer comfort is required.

### *D.5 Heating Load (Btu/h)*

Record the heating load (heat loss) for each room. These loads are found in the heat loss/gain calculations.

### *D.6 Room Heating Flow Rate*

Using the formula **(D.5 x C.4)**, calculate and record the room flow rate (cfm). This calculation is used to determine the room flow rates for winter heating and must also be used to determine the minimum room flow rates for systems designed for both heating and cooling.

**Note:** The above practice ensures the cfm requirements are enough to maintain room temperatures of all living spaces at a minimum of 72°F.

### *D.7 Number of Outlets Per Room*

Record the number of outlets per room. Using the room flow rate of either D.4, D.6 or both, determine the number of outlets that adequately bathe the exterior walls, windows and doors. The deciding factors considered in determining the number of outlets are the amount of air flow to be delivered, the expanse of exposed wall to be bathed and the register or diffuser throw, spread and face velocity.

**Note:** At this point in the design procedure, the house floor plans must be studied to help determine the number and the location of supply air outlets.

### *D.8 Floor Supply Air Flow Rates*

Record the total supply air flow rate. The total floor supply air flow rate is the accumulation of all room flow rates and is found by adding together the highest of each room cfm found on either line D.4 or line D.6.

## 3.6 Part E Inlet Flow Rates

### *E.1 Floor Return Air Flow Rate*

Record the inlet flow rates. Beginning with the basement, determine the maximum cfm (usually 50% of supply air) designed to help prevent a negative pressure in the basement. This is generally considered good practice as it may also help reduce the intake of soil gases etc. To calculate the basement return air flow, multiply the floor supply air D.8 by .50 (50%). The remaining return air flow (50%) must then be returned from another location or floor. It is recommended that this air flow be added to the second floor return air volume (if applicable), as it is believed that the higher return volume will improve circulation. In cases where this is not practical, add a portion or all to the first floor. Both 1st and 2nd floor return air volumes may be increased, but in no case, are they to be less than the volumes at their respective flow rates on line D.8. The total of all return air flow rates must equal the total of all supply air flow rates (line D.8).

**Note:** When outside air (ventilation) is introduced into the return air trunk duct, it may be considered a branch duct and therefore part of the return air system. In this situation, the ventilation cfm (A.8) may be used to offset the leftover balance of the basement return air thus reducing the need to add return air volume to the 1st and 2nd floors.

### *E.2 Minimum Number of Openings*

Record the minimum number of return air plate openings. Beginning with the basement, calculate the minimum number of openings. Unfinished basements are only likely to require one inlet as the return air has been reduced to a smaller quantity and its branch (panned floor joists) would have the capacity to handle a much larger volume ( 300-400 cfm) of air than a plate opening. Finished basements can be determined by the same practice required for upper floors. To determine the minimum number of plate openings for 1st or 2nd floor inlets when wall or baseboard grilles are to be used (Figure 3.3), the following formula will apply:

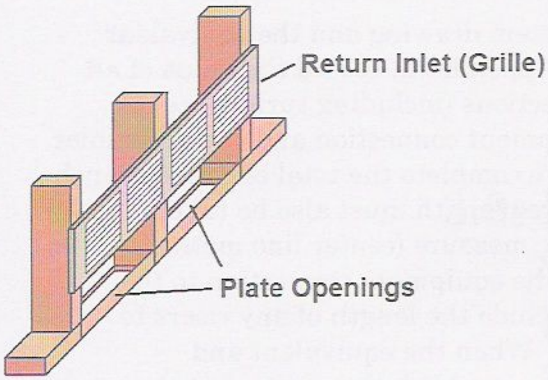



Figure 3.3

**Floor return air cfm (E.1) ÷ 120 = minimum number of plate openings.**

**Note:** The 120 cfm factor represents the air flow permissible through a wall plate opening of 3-1/4" x 14" using average residential duct system pressures. When friction rates and velocities permit, greater volumes per plate opening are possible. Walls of greater width i.e. 2" x 6" will have much larger plate openings and therefore are able to permit greater air volumes (180 cfm or more).

### *E.3 Actual Number of Openings*

Record the actual number of openings. Once the minimum number of openings is established, the floor circulation may be improved by increasing the number of return air openings. When this is the case, record the new number of openings.

### *E.4 Actual cfm Per Opening*

Using the formula **(E.1 ÷ E.3)**, calculate and record the actual cfm per opening.

**Note:** At this point of the design procedure, the house floor plans must be studied to determine the location of the return air inlets and the supply air outlets. After the positioning of both supply outlets, return inlets and the heating equipment, it is recommended that at least a single line diagram be

produced (preliminary drawings) showing the entire duct system.

## 3.7 Part F Summary of Total Effective Lengths For Return Ducts (page 4)

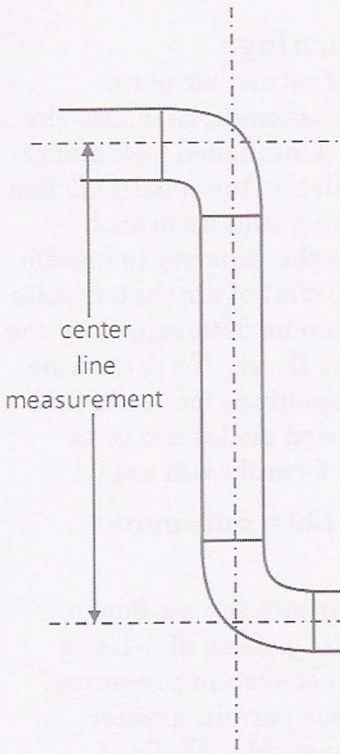



Figure 3.4

From the duct system drawing and the equivalent lengths found in Appendix B, record the value of all fittings and connections (including turbulence) between the equipment connection and the grille inlet of each branch. To complete the total effective branch lengths, a measured length must also be taken. At the drawing scale, measure (center line method Figure 3.4) from the equipment connection to the grille inlet and include the length of any risers to other floor levels. When the equivalent and measured lengths are added, they represent the total effective length of the branch. This effective length reflects the frictional and dynamic losses encountered by the air while passing from the equipment to the end of the branch.

## 3.8 Part G Duct Design Pressure

### *G.1 Return Branch Longest Effective Length*

From the summary of total effective lengths, record the length of the longest branch run. This length will be used to establish the apportioning factor found in Appendix C (C3).

### *G.2 R/A Plenum Pressure*

Record the return air plenum pressure. This pressure is found by multiplying the available design pressure (C.9) by the return air apportioning factor from Appendix C (C3). In some instances the pressure, when calculated, will be at three decimal places. Duct design charts and calculators only calculate to two decimal places, and therefore the pressure must also be rounded off to two places. It is common practice to round the return air pressure down and the supply air pressure up. These duct design pressures are ultimately responsible for the

eventual main trunk velocities. As the supply trunk has a higher recommended velocity (see Appendix C (C2)), we are usually able to allot more of the design pressure to the supply. On the occasion where there is a much shorter or simpler supply air system, the pressures may then be rounded off in reverse. This pressure is re-recorded on line H.8.

### *G.3 S/A Plenum Pressure*

Record the supply air plenum pressure. This pressure is found by subtracting the return air plenum pressure (G.2) from the available design pressure (C.9). This pressure is re-recorded on line J.7.

## 3.9 Part H Sizing of Return Grilles, Branches and Main Trunk Ducts (page 5)

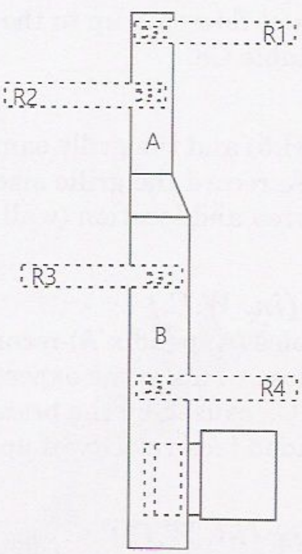



Figure 3.5

### *H.1 Trunk Letter/No*

Identify each section of the main trunk either by letter (most popular) or number. The change in section (size) is dictated by the location of the trunk transition (see Figure 3.5). To determine the transition location, study the preliminary drawings produced after completing parts D and E of the worksheets. To be useful, a trunk transition must be located where a significant gain in velocity and a reasonable reduction in duct size can be achieved. It is suggested that, when one transition is to be used, the transition be located after approximately 50% of the air volume has been collected by the main trunk duct. If two transitions are used then 33% and 66%, etc.

### *H.2 Inlet Location (Room)*

Record the name of the room in which each inlet is located. Room inlets must be recorded in the correct sequence. The first room inlet recorded is the one connected to the main return air trunk most remote from the return air plenum. The remaining room inlets are recorded in sequence progressing downstream toward the return air plenum. This practice ensures that the accumulated trunk flow rate recorded on line H.15, is in the correct order and proportion.

### *H.3 Inlet No (R)*

Record the return air branch inlet number (one per column). For easy identification each branch will be allotted a number prefixed by the letter "R". It is common practice to number the branch most remote from the plenum "R1" (see Figure 3.5).

### *H.4 Inlet Flow Rate (cfm)*

Record the inlet flow rate for each branch. The inlet flow rate is found by taking the actual cfm per opening line E.4 and multiplying by the number of plate openings (usually one or two) determined from the preliminary drawings.

**Note:** When the return air system is designed using floor type inlets, then the limiting space factor of plate openings would only apply to upper floors. This is because the air flow would still have to be routed through partition walls.

### *H.5 Minimum Required Inlet Free Area (sq. in.)*

Using the inlet flow rate line H.4 and the grille free area table, Appendix C (C8), determine the minimum free area of each return air grille.

**Note:** Always round the inlet flow rate up to the nearest 10 cfm for use on table C8.

### *H.6 Inlet Size*

Using the inlet free area (H.5) and the grille sample tables found in Appendix A, record the grille size suitable for both the free area and location (wall or floor type).

### *H.7 Inlet Pressure Loss (in. W.C.)*

From the grille sample tables (Appendix A) record the inlet (grille) pressure loss. This is the expected pressure loss (drop) in. W.C., caused by the branch flow rate at the recommended face velocity of up to 400 fpm.

### *H.8 R/A Plenum Pressure (in. W.C.)*

From line G.2 (R/A Plenum Pressure), record the allotted pressure for the return air portion of the system. This pressure will be the available pressure for the design (sizing) of each branch run.

### *H.9 Adjusted Duct Design Pressure*

Using the formula (**H.8 - H.7**), calculate the adjusted duct design pressure to two decimal places. This remaining pressure is then available to design (size) each return air branch.

**Note:** When rounding off duct design pressures, it is good practice to round down for .004 in. W.C. or less and round up when .005 in. W.C. or greater.

### *H.10 Branch Effective Length (ft.)*

From part F, record the effective lengths of all return air branch runs. These lengths will be used to establish the friction rate per/100 ft. This is the rate (in. W.C.) at which the duct design pressure is consumed/ per/100ft of effective length.

### *H.11 Loss/100 ft of Effective Length*

Using the formula, **[(H.9 x 100) ÷ H.10]**, calculate the loss/100 ft of effective length. These adjusted pressure rates, reflect the rate at which pressure is to be consumed by the air flow while overcoming the actual effective length of the branch.

### *H.12 Branch Duct Size (Round)*

Using the equal friction chart or table of air friction in metal ducts (Appendix C (C4, C5)), the inlet flow rate (H.4) and the loss/100 ft of effective length (H.11), determine the branch duct diameter to the nearest 1/2 inch and record. When sizing a branch with a double plate opening, use the combined cfm of both plate openings. This diameter would be used to size a rectangular branch in situations where joist space cavities were not available. To complete the branch sizing for double plate openings, divide the cfm equally to each plate and size for the same pressure (friction) rate.

### *H.13 Branch Rectangular Equivalent*

Using the branch diameter (H.12) and the rectangular equivalent table (Appendix C (C6)), determine a suitably shaped rectangular equivalent.

**Note**: In most cases, the building structure, i.e. joist and stud spaces, are used as return air branch ducts. When the design does incorporate building structure openings, i.e. stud plate openings, choose an equivalent stack or riser size (i.e. 3-1/4" x 14") from the rectangular equivalent table.

### *H.14 Joist to Trunk Opening Size*

Using the formula **(2 x area H.13)**, calculate the joist to trunk opening size (Figure 3.6). It is recommended that the joist to trunk opening be sized to double that of the rectangular equivalent (H.13) and in no case, should it be less than 1-1/2 times the area of H.13. This area (sq in) can then be converted into the

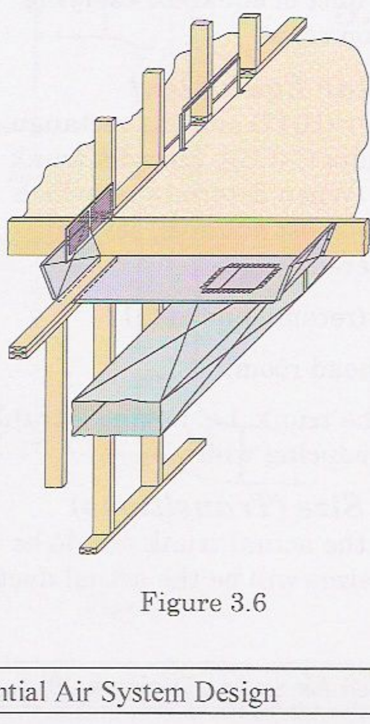


Figure 3.6

opening shape. The most suitable and efficient shape (square) should be considered.

### *H.15 Trunk Flow Rate (cfm)*

Using line H.4 and beginning with the branch most remote from the plenum (usually R1), accumulate the branch cfm in order until all branches between the trunk end and the plenum have been accumulated. This cfm will then be used to determine the trunk size at any location along its length.

### *H.16 Lowest Loss/100 ft*

Using line H.11, record the lowest branch loss/100 ft (in. W.C.). This loss is recorded beginning with the branch at the end of the trunk (usually R1) and then recording progressively, the lowest branch loss encountered while working toward the plenum.

**Note:** The purpose of this practice is to ensure that the trunk is never undersized for any branch. When each branch is sized by a friction rate/100 ft (in. W.C.), it is necessary that this rate be constant or no higher from grille to plenum. Otherwise, a branch may encounter a loss/100 ft greater than the branch was sized for, thereby imposing a restriction in the trunk.

### *H.17 Trunk Duct Size (round)*

Using the accumulated trunk flow rate (H.15), the lowest loss/100 ft (H.16) and the equal friction chart or table of air friction in metal ducts (Appendix C (C4, C5)), record the trunk diameter. This diameter recorded to the nearest 1/2" will be used to determine a square or rectangular duct of equal air carrying capacity (cfm) and friction rate.

### *H.18 Trunk Rectangular Equivalent*

Using the trunk diameter (H.17) and the rectangular equivalent table (Appendix C (C6)), record a trunk rectangular equivalent. When determining which rectangular equivalent is most suitable, several factors should be considered:

1. the duct aspect ratio (recommended 2:1)
2. the available space (head room)
3. the streamlining of the trunk, i.e. having a trunk with constant depth and reducing width.

### *H.19 Installed Trunk Size (Transitions)*

Using line H.18, record the actual trunk size to be installed. These trunk sizes will be the actual duct

size recorded between the duct end and the first transition, then the duct size between transitions (when applicable) and finally the duct size between the last transition and the plenum.

**Note:** The position of each transition will correspond with the trunk division shown on line H.1.

### *H.20 Trunk Velocity (fpm)*

Using the formula **[(cfm x 144) ÷ area]**, calculate the trunk velocity (fpm), where 144 is the number of square inches in a square foot and area is the cross sectional area of duct in square inches. This calculation must be performed for the highest point of duct velocity and will normally occur at the plenum entry and at the reducing end of a transition.

**Note:** The purpose of calculating the trunk velocity is to ensure that it is within the recommended limits (Appendix C (C2)). There is a direct relationship between duct velocity and air speed noise. If the calculated velocity is found to be over the recommended limit, it may be possible to reduce both the velocity and noise by increasing the trunk width until the calculated velocity drops to the recommended limit. When trunk velocities are over their limits, it could indicate that the duct design pressure allowed for the return air system was excessive and may have to be re-evaluated.

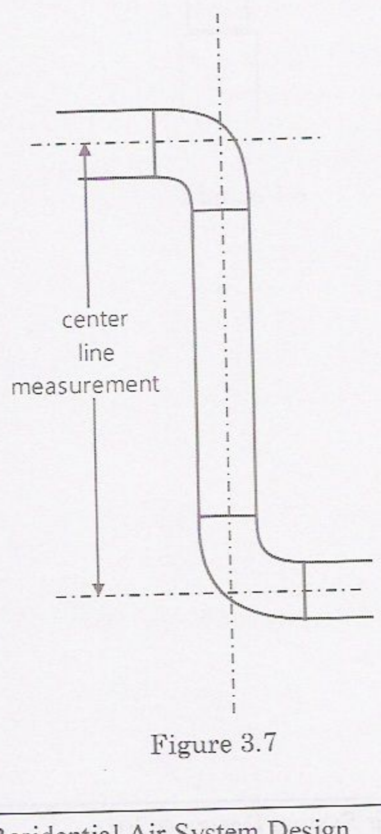



Figure 3.7

## 3.10 Part I Summary of Total Effective Lengths For Supply Ducts (page 6)

From the duct system drawing and the equivalent lengths found in Appendix B, record the value of all fittings and connections (including aspiration) between the equipment connection and the diffuser outlet of each branch. To complete the total effective branch lengths, a measured length must also be taken at the drawing scale. Measure, using center line method (see Figure 3.7) from the equipment connection to the diffuser outlet and include any risers to other floor levels. When the equivalent and

measured lengths are added, they represent the total effective length of the branch.

This effective length reflects the frictional and dynamic losses encountered by the air while passing through the branch.

# 3.11 Part J

## Sizing of Supply Diffusers, Branches and Main Trunk Ducts (page 7)

### *J.1 Trunk Letter/No*

Identify each section of the main trunk either by letter (most popular) or number. The change in section (size) is dictated by the location of the trunk transition (see Figure 3.8). To determine the transition location, study the preliminary drawings produced after completing parts D and E. To be useful, a trunk transition must be located where a significant gain in velocity is achieved and also a reasonable reduction in duct size. When one transition is to be used, locate the transition after approximately 50% of the air volume has been collected by the main trunk duct. For transitions, use 33%, etc.

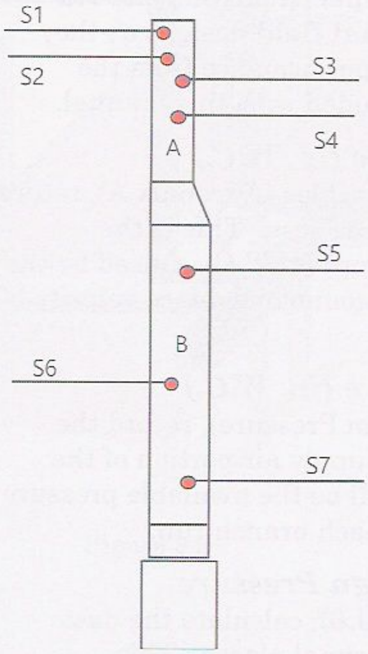


Figure 3.8

### *J.2 Outlet Location (Room)*

Record the name of the room in which an outlet is located. Room outlets must be recorded in the correct sequence. The first room outlet recorded is the one connected to the main supply air trunk most remote from the supply air plenum. The remaining room outlets are recorded in sequence progressing upstream toward the supply air plenum. This practice ensures that the accumulated trunk flow rate recorded on line J.13, is in the correct order and proportion.

### *J.3 Outlet No (S)*

Record the supply air branch outlet number (one per column). For easy identification, each branch will be prefixed with the letter "S" followed by a number. It is common practice to number the branch most remote from the plenum "S1" (see Figure 3.8).

### *J.4/J.4b Outlet Flow Rate (cfm)*

Record the outlet flow rate for each branch. The outlet flow rate is found by taking the actual cfm per room (line D.6 or D.4) and dividing by the number of outlets per room (line D.7).

### *J.5 Outlet Size*

Using the diffuser sample tables found in Appendix A, select a diffuser (register) with a good spread, throw and an acceptable face velocity. The most common diffusers (3" x 10" and 4" x 10") perform well with most residential branch volumes.

**Note: Manufacturer's specifications should always be used for actual field** designs as they may vary significantly in performance from the generic specifications included with this manual.

### *J.6 Outlet Pressure Loss (in. W.C.)*

From the diffuser sample tables (Appendix A), record the outlet (diffuser) pressure loss. This is the expected pressure loss (drop) in. W.C., caused by the branch flow rate at the recommended face velocity of up to 500 fpm.

### *J.7 S/A Plenum Pressure (in. W.C.)*

From line G.3 (S/A Plenum Pressure), record the allotted pressure for the supply air portion of the system. This pressure will be the available pressure for the design (sizing) of each branch run.

### *J.8 Adjusted Duct Design Pressure*

Using the formula **(J.7 - J.6)**, calculate the duct design pressure to two decimal places. This remaining pressure is then available to design (size) each supply air branch.

### *J.9 Branch Effective Length (ft.)*

From part I, record the effective lengths of all supply air branch runs. These lengths will be used to establish the friction rate per/100 ft (in. W.C.). This is the rate at which the duct design pressure is consumed.

### *J.10 Loss/100 ft of Effective Length*

Using the formula **[(J.8 x 100) ÷ J.9]**, calculate the loss/100 ft of effective length. These adjusted pressure rates reflect the rate at which pressure is to be consumed by the air flow while overcoming the effective length of the branch.

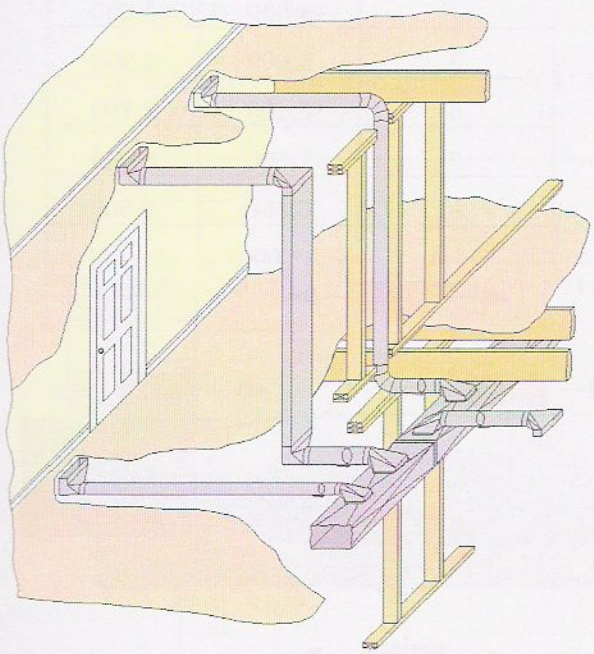


Figure 3.9

### J.11 Branch Duct Size (Round)

Using the equal friction chart or table of air friction in metal ducts (Appendix C (C4, C5)), the outlet flow rate (J.4) and the loss/100 ft of effective length (J.10), determine the branch duct diameter and record. These branch diameters are the actual installed sizes and therefore must be whole number sizes i.e. 4", 5" or 6". When rounding off the diameters, any duct at 0.3" or less is rounded down and 0.31" and above is rounded up.

### J.12 Branch Rectangular Equivalent

Using the branch diameter (J.11) and the rectangular equivalent table (appendix C (C6)), determine a suitably shaped rectangular equivalent stack or riser size.

**Note:** For branches that have to be converted to rectangular stack sizes (Figure 3.9) and are required to pass between partition walls, choose a stack or riser size i.e. 3-1/4" x 10".

### J.13/J13b Trunk Flow Rate (cfm)

Using line J.4 and or J.4b and beginning with the branch most remote from the plenum (usually S1), accumulate the branch cfm in order, until all branches between the trunk end and the plenum have been accumulated. This cfm will be used to determine the trunk size at any location along its length. Each trunk will be sized using the greatest accumulation of either heating or cooling airflow.

***See following examples (method A or B) for accumulation of trunk airflow:***

Note: *Method A* would be considered a superior design option when effective branch dampening is provided. This option would help ensure that the correct amount of airflow be delivered for both winter heating and summer cooling.

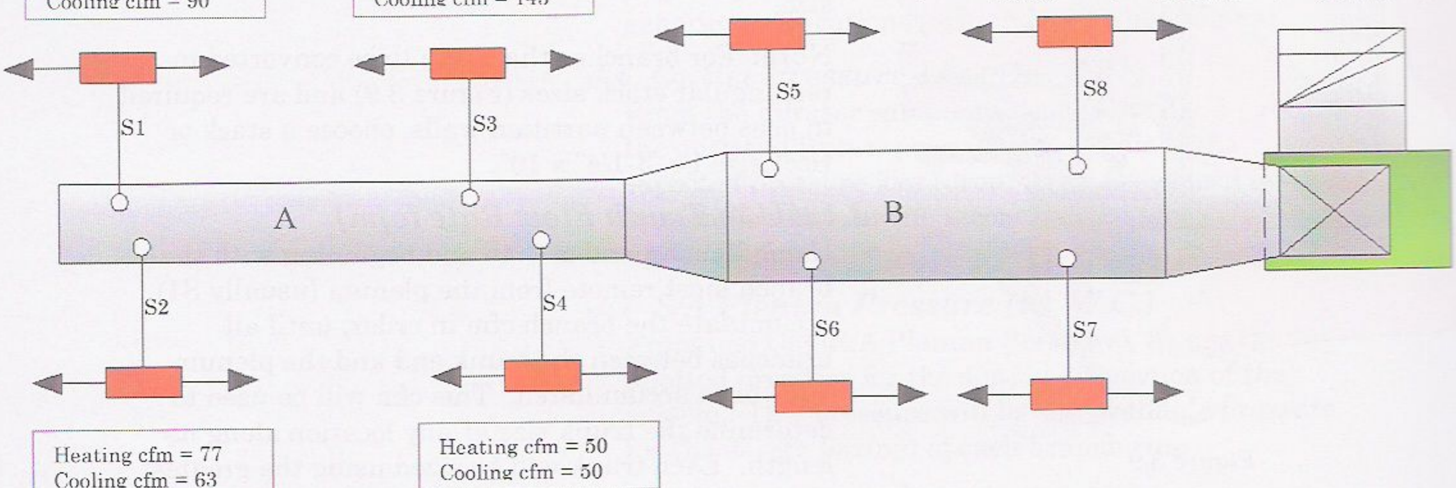
Note: *Method B* would be considered a design option when cooling air distribution is not a major concern. This option would help ensure that the correct amount of airflow be delivered for winter heating distribution and would be reasonable for summer cooling.

Example: *Method A*

Design heating = 42,000 Btuh, with 700 cfm system design airflow. Heating airflow factor (B.4 ÷ A.1) = 700 ÷ 42,000 = *0.0167* cfm/Btuh

Design cooling = 24,000 Btuh, with 800 cfm system design airflow. Cooling airflow factor (B.7 ÷A.4) = 800 ÷ 24,000 = *0.0333* cfm/Btuh

| Branch S/A # | Btuh/Heat | Btuh/Cool |
|---|---|---|
| | | |
| 1 | 5,500 | 2,700 |
| 2 | 4,600 | 1,900 |
| 3 | 6,000 | 4,300 |
| 4 | 3,000 | 1,500 |
| 5 | 5,000 | 2,900 |
| 6 | 4,400 | 2,200 |
| 7 | 7,500 | 5,600 |
| 8 | 6,000 | 2,900 |
| Totals | 42,000 | 24,000 |




Note: Accumulation of trunk airflow at trunk B would never exceed the design airflow of either heating or cooling.

Example:

Heating airflow trunk A = 319 cfm.

Cooling airflow trunk A = 346 cfm.

Trunk A accumulation therefore is 346 cfm.

Trunk B accumulation is 800 cfm, (highest of heating or cooling design airflows).

Note: With method A, distribution of both heating and cooling airflow is matched exactly to the room loads. This is only true if "effective" balancing dampers are installed and set accordingly.

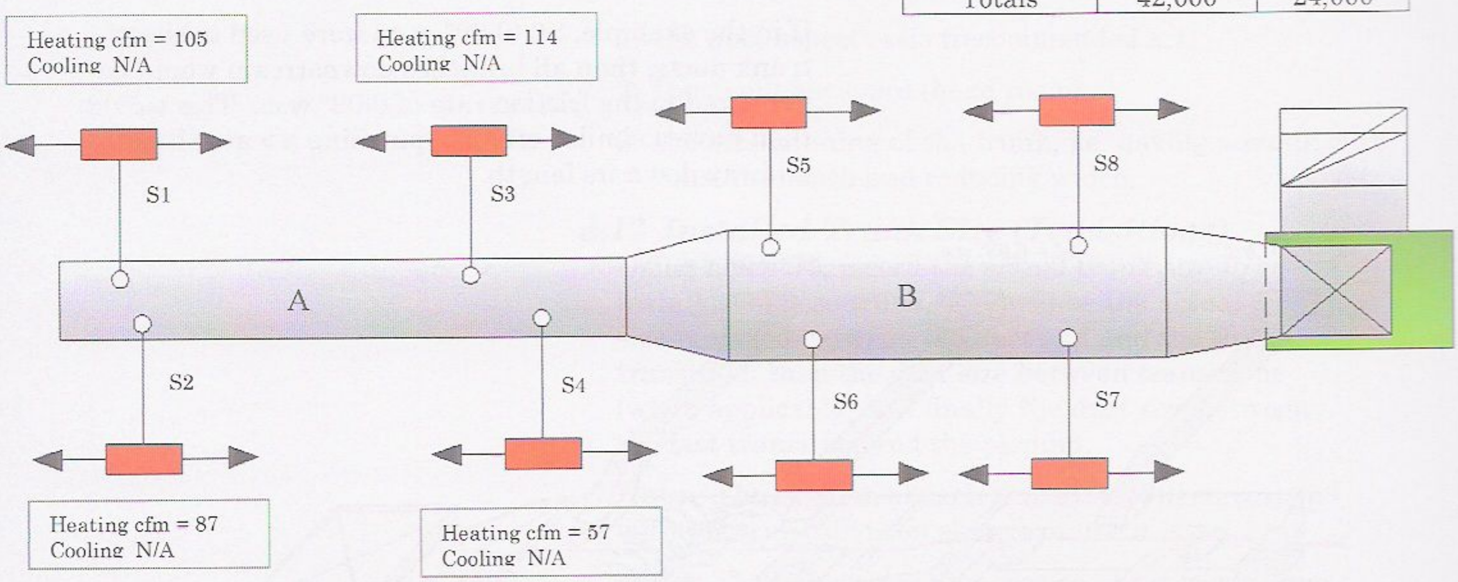
Example: *Method B*

Design heating = 42,000 Btuh, with 700 cfm system design airflow.

Design cooling = 24,000 Btuh, with 800 cfm system design airflow.

Design airflow factor (C.2 ÷ A.1) = 800 ÷ 42,000 = *0.0190* cfm/Btuh

| Branch S/A # | Btuh/Heat | Btuh/Cool |
|---|---|---|
| 1 | 5,500 | 2,700 |
| 2 | 4,600 | 1,900 |
| 3 | 6,000 | 4,300 |
| 4 | 3,000 | 1,500 |
| 5 | 5,000 | 2,900 |
| 6 | 4,400 | 2,200 |
| 7 | 7,500 | 5,600 |
| 8 | 6,000 | 2,900 |
| Totals | 42,000 | 24,000 |




Example:

Heating airflow trunk A = 363 cfm.

Cooling airflow trunk A = N/A

Trunk A accumulation therefore is 363 cfm.

Trunk B accumulation is 800 cfm, (highest of heating or cooling design airflows, see (C.2).

Note: Accumulation of trunk airflow at trunk B would never exceed the design airflow of either heating or cooling.

Note: With method B, distribution of airflow is matched to the heating loads only. The actual heating airflow is less than the design airflow and this may help with summer cooling sizing. Branch balancing dampers are still required.

### *J.14 Lowest Loss/100 ft*

Using line J.10, record the lowest branch loss/100 ft (in. W.C.). This loss is recorded beginning with the branch at the end of the trunk (usually S1) and then recording progressively, the lowest loss encountered while working toward the plenum.

**Note:** The purpose of this practice is to ensure that the trunk is never undersized for any branch. When each branch is sized by a friction rate loss/100 ft (in. W.C.). This rate must be constant or no higher from diffuser to plenum. Otherwise, a branch may encounter a loss/100 ft greater than it was sized for, thereby imposing a restriction in the trunk duct. See (Figure 3.10) example below.

If in the example, S6 (0.09" w.c.) were used to size the trunk ducts, then all branches downstream would be subjected to the friction rate of 0.09" w.c.. This would then have a similar effect to pinching a water hose midway down its length.

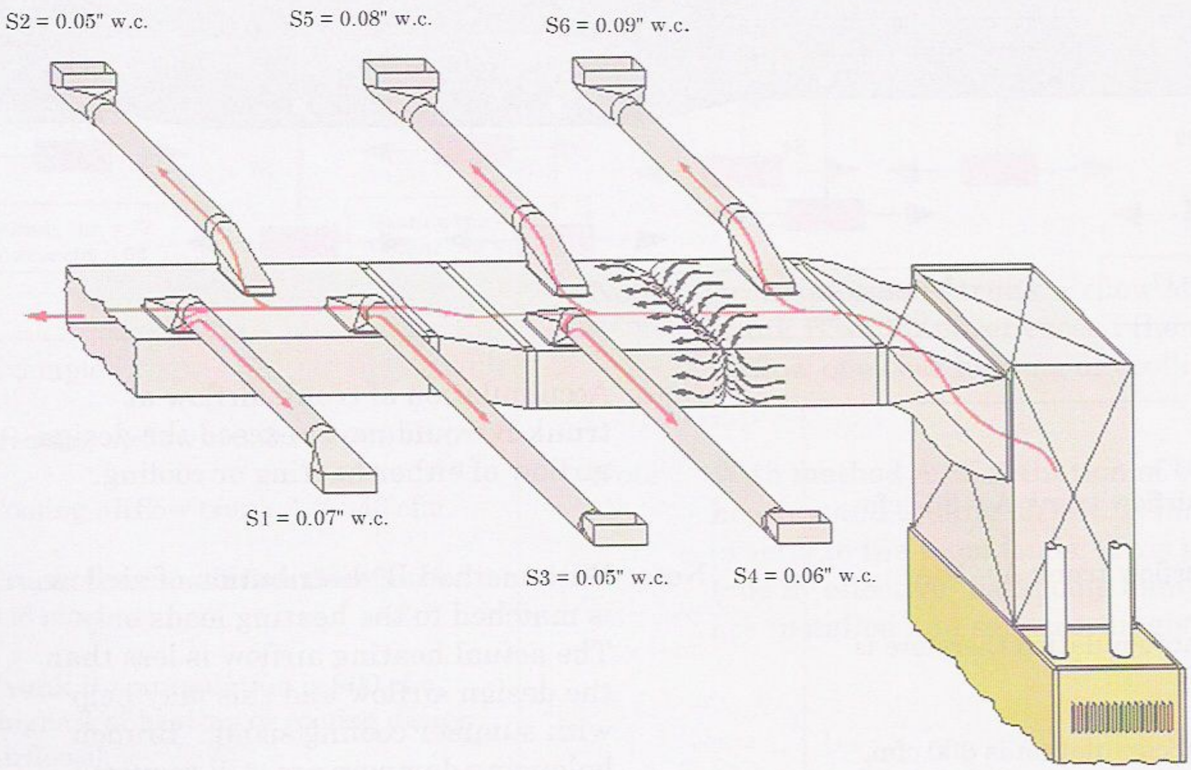



Figure 3.10

### *J.15 Trunk Duct Size (Round)*

Using the accumulated trunk flow rate (J.13), the lowest loss/100 ft (J.14) equal friction chart or table of air friction in metal ducts (Appendix C (C4, C5)),record the trunk diameter. This diameter recorded to the nearest 1/2" will be used to determine a square or rectangular duct of equal air carrying capacity (cfm) and friction rate.

### *J.16 Trunk Rectangular Equivalent*

Using the trunk diameter (J.15) and the rectangular equivalent table (Appendix C (C6)), record a trunk rectangular equivalent. When determining which rectangular equivalent is most suitable, several factors should be considered:

1. the duct aspect ratio (recommended 2:1)
2. the available space (head room)
3. the streamlining of the trunk, i.e. having a trunk with constant depth and reducing width.

### *J.17 Installed Trunk Size (Transitions)*

Using line J.16, record the actual trunk size to be installed. These trunk sizes will be the actual duct size recorded between the duct end and the first transition, then the duct size between transitions (when applicable) and finally the duct size between the last transition and the plenum.

**Note:** The position of each transition will correspond with the trunk division shown on line J.1.

**Note**: The Return Air drop size can be selected from the Rectangular Duct Equivalents chart (C6). Find a round pipe size appropriate for the System Design Airflow (worksheet C.2). Select a duct width as close as possible to the width of the Return Air opening of the heating/cooling equipment or filter size.

### *J.18 Trunk Velocity (fpm)*

Using the formula **[(cfm x 144) ÷ Area]**, calculate the trunk velocity (fpm), where 144 is the number of square inches in one square foot and area is the cross sectional area of the duct in square inches. This calculation must be performed for the highest point of duct velocity and will normally occur at the plenum exit and at the reducing end of a transition.

**Note**: The purpose of calculating the trunk velocity is to ensure that it is within the recommended limits (Appendix C (C2)). There is a direct relationship

between duct velocity and air speed noise. If the calculated velocity is found to be over the recommended limit, it may be possible to reduce both the velocity and noise by increasing the trunk width until the velocity drops to the recommended limit. When trunk velocities are over their limits, it could indicate that the duct design pressure allowed for the supply air system was excessive and may have to be re-evaluated.

# 4 WORKSHEET EXAMPLES

## 4.1 Example # 1 (Red Deer)

*Customer:*

Mr. Smith, 16 Queen St.,
Red Deer, Alberta ***Z0Z-1K1***
Phone and fax ________

*Location:*

The house is to be constructed in Red Deer, Alberta. House volume is 24,310 cu. ft. **Re: Page 2 RHLG worksheet.**

*Design Conditions:*

**Note:** Specification sheets for the mechanical equipment required can be found in Appendix A of this manual

*Heating:*

The heating unit will be a DLM gas fired Variable Output C/W ECM motor forced air furnace properly sized for the calculated heat loss including ventilation.

*Cooling:*

The cooling unit will be a DLM 14.5 SEER central air conditioner properly sized for the calculated heat gain including ventilation.

*Air Cleaner:*

This furnace is not supplied with a standard 1" fiberglass filter, the owner requests a 16" x 25" Merv 16 Air filter to be installed.

*Duct System:*

The duct system shall conform to the duct layout drawings and floor plans on the following pages and designer estimates **0.3" w.c. design pressure** for duct system.

*Ventilation:*

Customer selects model HRV3-150 to meet 100 CFM ventilation flow rate required and therefore duct system is used for the distribution of ventilation air.

*Floor Registers:*

Customer selects 10 × 4 metal floor registers and requires distribution for heating and cooling.

**Note:** As ventilation air is introduced into the duct system, a mixed air temperature calculation is required.

**HRAI Residential Heat Loss and Heat Gain Calculations** Page 2

**SECTION B — DESIGN CONDITIONS**

| HEAT LOSS | | | HEAT GAIN | | |
|---|---|---|---|---|---|
| Outdoor Design Temperature Heating(ODT) | -26 | °F / ~~°C~~ | Outdoor Design Temperature Cooling (ODT) | 84 | °F / ~~°C~~ |
| Indoor Design Temperature (IDT) | 72 | °F / ~~°C~~ | Indoor Design Temperature (IDT) | 75 | °F / ~~°C~~ |
| Mean Soil Temperature | 41 | °F / ~~°C~~ | North Latitude | 52 | ° |
| | | | Summer Mean Daily Temperature Range | 25 | °F / ~~°C~~ |
| Building Volume (Vb) | 24310 | $ft^3$ / ~~$m^3$~~ | Building Conditioned Area | 2860 | $ft^2$ / ~~$m^2$~~ |

HRV Apparent Sensible Effectiveness = 0.76 (insert N/A if no HRV/ERV installed)

Ventilation System:

☐ Case #1: Exhaust Only System ☐ Case #2: Direct Ducted System ☑ Case #3: Central Forced Air Syst

**SECTION C — ROOM HEAT LOSS / HEAT GAIN SUMMARY**

| Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ | Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ |
|---|---|---|---|---|---|---|---|
| 1 | Basement | 15295 | 2096 | | | | |
| 2 | Bath | 1695 | 797 | | | | |
| 2 | Bed 1 | 2187 | 1496 | | | | |
| 2 | Bed 2 | 2096 | 1139 | | | | |
| 2 | Kitchen | 2065 | 1891 | | | | |
| 2 | Dining | 4287 | 2782 | | | | |
| 2 | Living | 5122 | 4695 | | | | |
| 2 | Entrance | 1764 | 1028 | | | | |
| 2 | Master Bed | 4196 | 3282 | | | | |
| | | | | SUB TOTAL | | 38707 Section 18 | 19206 Section 21 |

**SECTION D — BUILDING HEAT LOSS SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Loss | (Section 18) | 38707 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Loss | (Section 19) | 10584 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Loss** | (Section 20) | **49291** | Btuh/~~W~~ | |

**SECTION E — BUILDING HEAT GAIN SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Gain | (Section 21) | 19206 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Gain | (Section 22) | 972 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Gain** | (Section 23) | **20178** | Btuh/~~W~~ | |

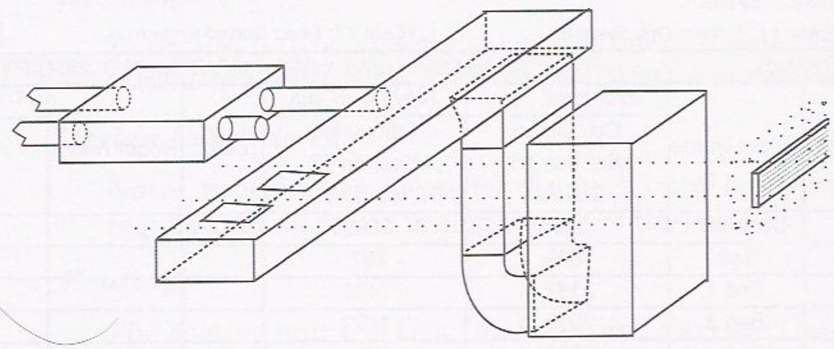
**Notes:**

Forms Available From: HRAI, 2350 Matheson Blvd. East, Suite 101
Mississauga, Ontario L4W 5G9

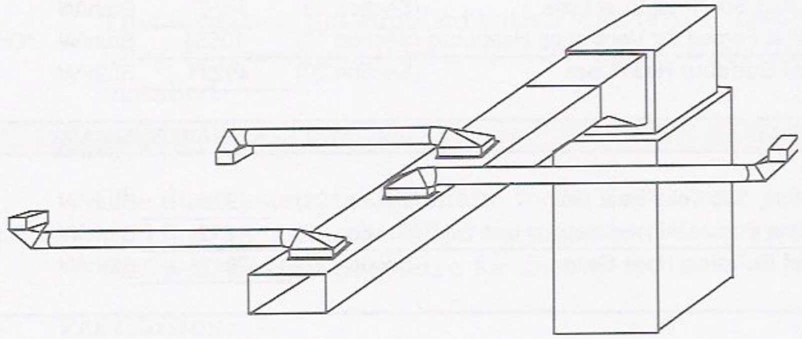
ver. Jul / 2017

**Note**: The following drawings demonstrate the general configuration of the ductwork near the furnace. Although not to scale nor complete in detail, they provide a clear indication of the fittings used and the path the air must follow as it enters and leaves the furnace.

*Return Air*

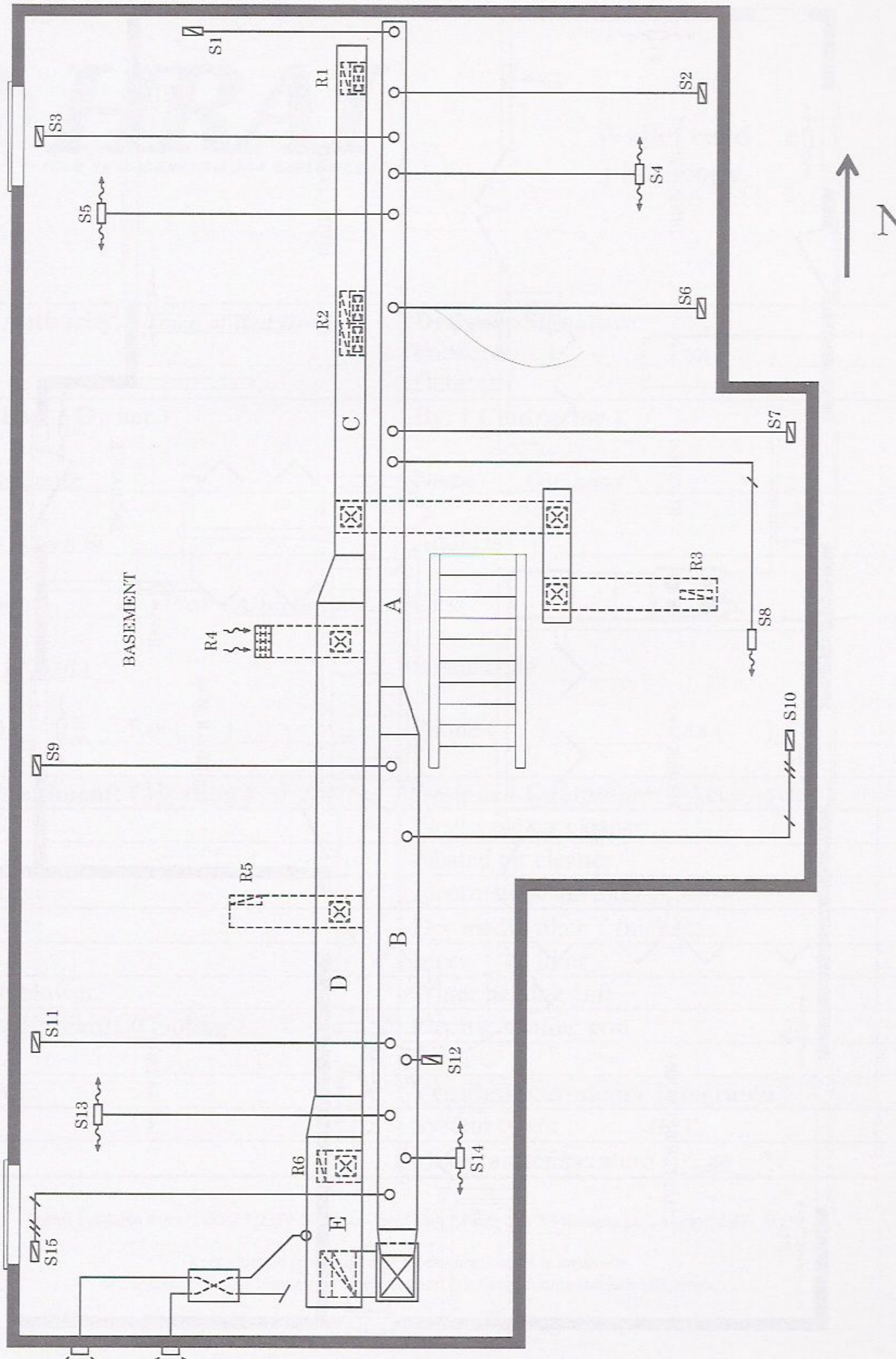


*Supply Air*



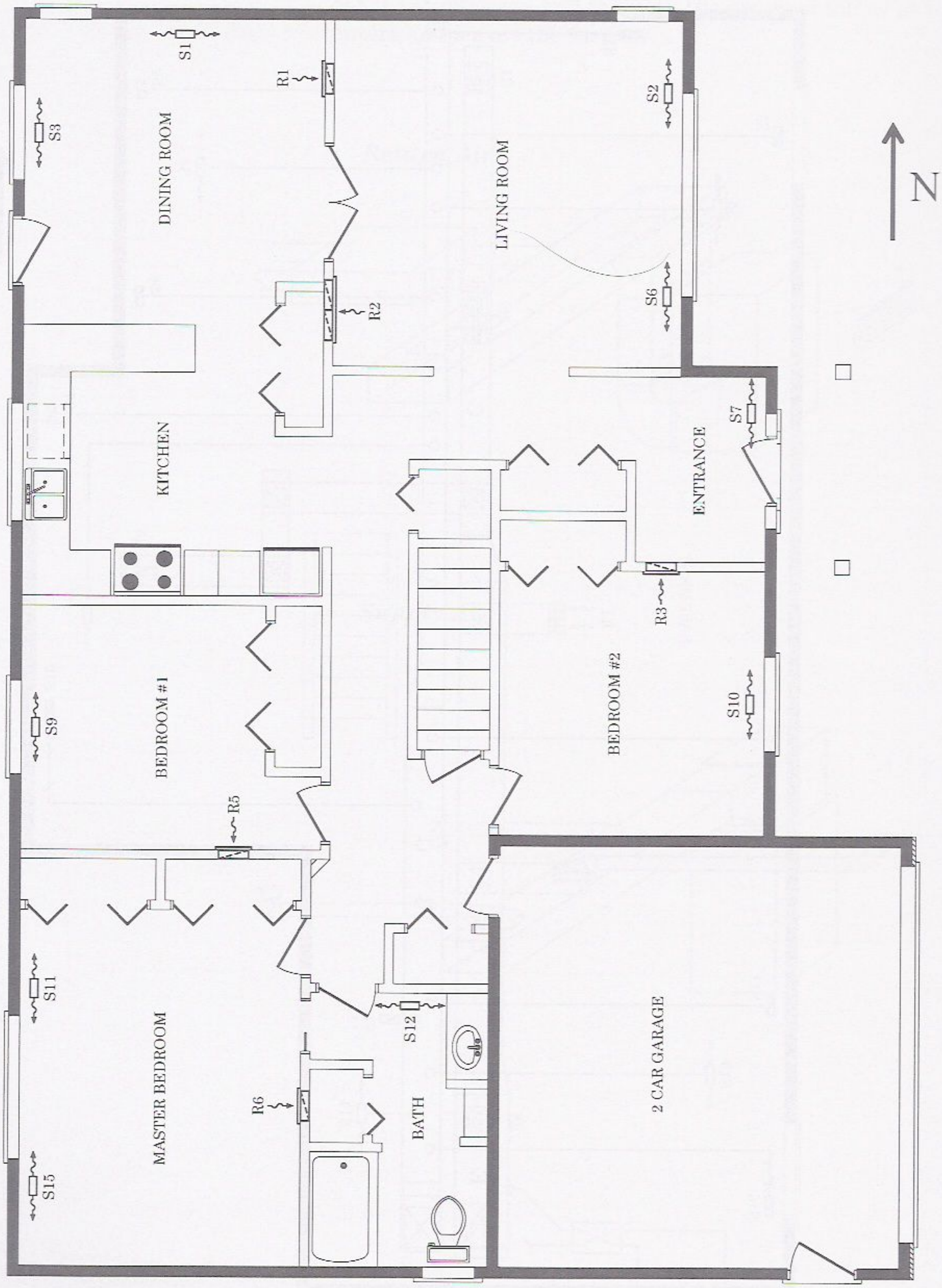
Red Deer (Basement)

Drawing not to scale



Red Deer (Main Floor)

Drawing not to scale



## WORKSHEET FOR RESIDENTIAL AIR SYSTEM DESIGN page 1

| HRAI YOUR ENVIRONMENT OUR EXPERTISE | Wallet card photocopy |
|---|---|
| **Inspection Authority:** _Town of Red Deer_<br>Signature: ____________<br>Date: / / | **Designer/Signature:** ____________<br>Phone: ( )______ Fax ( )______<br>Date: / / |
| **Submitted For: ( Owner )**<br>Name _Mr Smith_<br>Address _16 Queen St_<br>City _Red Deer_ Prov _Alberta_<br>Postal code _Z0Z-1K1_<br>Phone ( )______ Fax ( )______ | **By: ( Contractor )**<br>Name _Company_<br>Address ____________<br>City ____________ Prov ______<br>Postal code ______<br>Phone ( )______ Fax ( )______ |

| **Designed Equipment: ( Heating )** | | **Designed Equipment: ( Accessories )** | |
|---|---|---|---|
| Gas furnace | X | Electronic air cleaner | |
| Oil furnace | | Pleated air cleaner | |
| Propane furnace | | Electrostatic air filter | |
| Electric furnace | | Dry media filter ( thickness ) " | |
| Heat pump | | Merv _16_ filter | X |
| Water coil & blower | | Water heating coil | |
| **Designed Equipment: (Cooling )** | | Electric heating coil | |
| Indoor coil | X | Other | |
| Outdoor unit | X | **Ventilation System ( Integrated )** | X |
| Air handler | | System type : HRV | X |
| Other | | Mixed air temperature _66_ °F | |

Forms available from: HRAI * 2350 Matheson Blvd East * Suite 101 * Mississauga, Ontario * L4W 5G9

## PART A - DESIGN LOAD SPECIFICATIONS

page 2

| | | | |
|---|---|---|---|
| A.1 Sub Total Heat Loss | *38,707* Btuh. | | |
| A.2 Ventilation Heat Loss | *10,584* Btuh. | A.3 Total Heat Loss (A.1 + A.2) | *49,291* Btuh. |
| A.4 Sub Total Heat Gain | *19,206* Btuh. | | |
| A.5 Ventilation Heat Gain | *972* Btuh. | A.6 Total Heat Gain (A.4 + A.5) | *20,178* Btuh. |
| A.7 Volume of House: | (Heated Area) *2,860* X *8.5'* (Average Ceiling Height) | | *24,310* cu ft. |
| A.8 Ventilation Flow Rate: | As per Heat Loss/Gain Worksheet | | *100* cfm. |

## PART B – EQUIPMENT SELECTION

| Heating Equipment: | |
|---|---|
| Make *DLM* | Model *SLP98UH070V36* |
| Fuel Type: Gas Oil Electricity Other | |
| B.1 Heating Output (Minimum 100% - of A.3) | *64,000* Btuh. |
| B.2 Approved Temperature Rise/range | *50 - 80* °F. |
| B.3 Equipment External Static Pressure | *0.80* in. W.C. |
| B.4 Heating Air Flow Rate (blower specs) | *951* cfm |
| Speed setting: *Default* | Adjustment: *Default* |

| Cooling Equipment: | | |
|---|---|---|
| Make *DLM* | Model *13ACX-024-230* | (Outdoor Unit) |
| Make *DLM* | Model *CX34 – 18/24* | (Indoor Unit) |
| Cooling Medium: DX Chilled Water Other | | |
| B.5 Cooling Output (80% - 125% of A.6) *23,200* Btuh | *1.93* Tons | |
| B.6 Manufacturers Flow Rate/Ton | *400* (cfm/ton) | |
| B.7 Cooling Air Flow Rate. | | |
| Target Air Flow rate = B.5 X B.6 | *772* cfm | |
| Actual Air Flow Rate (blower specs) | *805* cfm | |
| B.8 Coil Pressure Drop, in. W.C. | Dry *.25* | Wet *.25* |
| Speed Setting: *Medium Low* | Adjustment: *-10%* | |

## PART C – AIR DISTRIBUTION & PRESSURE

| | | | |
|---|---|---|---|
| C.1 Circulation Air Flow Rate ( A.7 x 0.025 ) | *608* cfm | C.5 Calculated Heating Temperature Rise [ B.1 ÷ (B.4 x 1.08) ] | *62.3* °F |
| C.2 System Design Air Flow Rate (highest of B.4, B.7, C.1) | *951* cfm | C.6 Filter Pressure Drop | *0.15* in. W.C. |
| C.3 Cooling Airflow Proportioning Factor Calculate to 4 decimal places (B.7 ÷ A.4) | *0.0419* cfm/Btuh | C.7 Coil Pressure Drop (B.8) | *0.25* in. W.C. |
| C.4 Heating Airflow Proportioning Factor Calculate to 4 decimal places (C.2 ÷ A.1) or (B.4 ÷ A.1) | *0.0246* cfm/Btuh | C.8 Total of Pressure Drop (C.6 + C.7) | *0.40* in. W.C. |
| | | C.9 Available Design Pressure (B.3 C.8) or Selected Design Pressure | *0.40* in. W.C.<br>*0.30* in. W.C. |

**Note:** When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

| PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES | | | | | | | | page 3 |
|---|---|---|---|---|---|---|---|---|
| D.1 Floor | Main Floor | | | | | | | |
| D.2 Room | *M/Bed* | *Bed #1* | *Bed #2* | *Bath* | *Kit* | *Din* | *Liv* | *Ent* |
| D.3 Cooling load (Btuh) | 3,282 | 1,496 | 1,139 | 797 | 1,891 | 2,782 | 4,695 | 1,028 |
| D.4 Room cooling flow rate (D.3 x C.3) | 138 | 63 | 48 | 33 | 79 | 117 | 197 | 43 |
| D.5 Heating load (Btuh) | *4,196* | *2,187* | *2,096* | *1,695* | *2,065* | *4,287* | *5,122* | *1,764* |
| D.6 Room heating flow rate (D.5 x C.4) | *103* | *54* | *52* | *42* | *51* | *106* | *126* | *43* |
| D.7 Number of outlets per room | *2* | *1* | *1* | *1* | 0 | *2* | *2* | *1* |
| D.8 Floor supply air flow rates (greatest airflow heating or cooling) | *heat577-cool718* | | | | | | | |

| PART D - CONTINUED | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D.1 | *Basement* | | | | | | | | | | |
| D.2 | Base | | | | | | | | | | |
| D.3 | 2,096 | | | | | | | | | | |
| D.4 | 88 | | | | | | | | | | |
| D.5 | *15,295* | | | | | | | | | | |
| D.6 | *376* | | | | | | | | | | |
| D.7 | *5* | | | | | | | | | | |
| D.8 | *heat376-cool88* | | | | | | | | | | |

| PART E - INLET FLOW RATES | | | | | |
|---|---|---|---|---|---|
| Floor level (Location) | Basement (50% D.8 Max) | 1st floor (Sum of D.8 Min) | 2nd floor (Sum of D.8 Min) | 3rd floor (Sum of D.8 Min) | Total = ( C.2 ) (System cfm) |
| E.1 Floor return air flow rate | *188/88* | *(577+188)/718* | *N/A* | *N/A* | *953* |
| E.2 Minimum number of openings | *1* | *6+* | *N/A* | *N/A* | |
| E.3 Actual number of openings | *1* | *6* | *N/A* | *N/A* | |
| E.4 Actual cfm per opening ( E.1 ÷ E.3 ) | *188/88* | *128/120* | *N/A* | *N/A* | |

**Note:** After location of supply outlets and return inlets are determined, produce preliminary drawing.

## PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS page 4

| Inlet No | Equipment Connection (Group 1) | Trunk To Drop Connection (Group 1) | Trunk Transitions (Group 2) | Trunk Fittings (Group 2) | Duct To Joist (Group 3) | Turbulence Effect | Stud To Joist (Group 4) | Grille Opening To Stud (Group 4) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | C10 | B35 | 2-K30 | / | A¹25 | 80 | A15 | D10 | 56 | 261 |
| R2 | C10 | B35 | 2-K30 | / | A²60 | 40 | A15 | D10 | 45 | 245 |
| R3 | C10 | B35 | 2-K30 | / | A²60 + 2- A¹50 | 0 | B25 | D10 | 55 | 275 |
| R4 | C10 | B35 | K15 | / | A²60 | 40 | / | C10 | 32 | 202 |
| R5 | C10 | B35 | K15 | / | A²60 | 0 | B25 | D10 | 27 | 182 |
| R6 | C10 | B35 | / | / | A²60 | 40 | A15 | D10 | 14 | 184 |
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## PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length __275_ ft).

G.2 **R/A Plenum Pressure:**

Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

( 0.30 ) x ( 0.50 ) = ___0.15_ in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**

Available Design pressure (Line C.9) - R/A Plenum Pressure

( 0.30 ) - ( 0.15 ) = __0.15__ in. W.C. (Record Line J.7)

## PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS page 5

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H.1 Trunk Letter/No | C | | | D | | E | | | | |
| H.2 Inlet Location (Room) | *Din* | *Liv* | *Bed 2* | *Base* | *Bed 1* | *M/Bed* | | | | |
| H.3 Inlet No (R) | *R1* | *R2* | *R3* | *R4* | *R5* | *R6* | | | | |
| H.4 Inlet flow rate (cfm) (Line E.4 adjusted) | *128* | *256* | *128* | *188* | *128* | *128* | | | | |
| H.5 Minimum required inlet free area (sq. in.) (Appendix C8) | *47* | *94* | *47* | *68* | *47* | *47* | | | | |
| H.6 Inlet size (Appendix A) | *14×6* | *30×6* | *14×6* | *14×6* | *14×6* | *14×6* | | | | |
| H.7 Inlet Pressure Loss (in. W.C.) | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | | | | |
| H.8 R/A Plenum pressure (in. W.C.) (Line G.2) | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | | | | |
| H.9 Adjusted duct design pressure (H.8 - H.7) | *0.13* | *0.13* | *0.13* | *0.13* | *0.13* | *0.13* | | | | |
| H.10 Branch effective length (ft) (Part F) | *261* | *245* | *275* | *202* | *182* | *184* | | | | |
| H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10] | *0.05* | *0.05* | *0.05* | *0.06* | *0.07* | *0.07* | | | | |
| H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5) | *7.5* | *9.5 2-7.5* | *7.5* | *8.5* | *7.0* | *7.0* | | | | |
| H.13 Branch rectangular equivalent (Appendix C6) | *14× 3-1/4* | *2 - 14× 3-1/4* | *14× 3-1/4* | *13×5* | *14× 3-1/4* | *14× 3-1/4* | | | | |
| H.14 Joist to trunk opening size (2 x area H.13) | *10×9* | *2 - 10×9* | *10×9* | *13×10* | *10×9* | *10×9* | | | | |
| H.15 Trunk flow rate (cfm) accumulation of H.4 | *128* | *384* | *512* | *700* | *828* | *956* | | | | |
| H.16 Lowest loss/100 ft encountered from duct end. | *0.05* | *0.05* | *0.05* | *0.05* | *0.05* | *0.05* | | | | |
| H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5) | — | — | *12.5* | — | *15.0* | *16.0* | | | | |
| H.18 Trunk rectangular equivalent (Appendix C6) | — | — | *17×8* | — | *26×8* | *28×8* | | | | |
| H.19 Installed Trunk size (Transitions) | — | — | *18×8* | — | *26×8* | *30×8* | | | | |
| H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | *512* | | *573* | *574* | | | | |

## PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

| Outlet No | Plenum Fitting (Group 5) | Trunk Transition (Group 6) | Trunk Fittings (Group 6) | Trunk To Branch Take offs (Group 7) | Aspiration Effect | Duct Flex Length (ft) | Branch Elbows (Group 8) | Boot Fitting (Group 8) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| S1 | B10 | K5 | / | A40 | 0 | / | / | C50 | 57 | 162 |
| S2 | B10 | K5 | / | A40 | 10 | / | / | B30 | 59 | 154 |
| S3 | B10 | K5 | / | A40 | 20 | / | / | B30 | 60 | 165 |
| S4 | B10 | K5 | / | A40 | 30 | / | / | B30 | 53 | 168 |
| S5 | B10 | K5 | / | A40 | 40 | / | / | B30 | 53 | 178 |
| S6 | B10 | K5 | / | A40 | 50 | / | / | B30 | 51 | 186 |
| S7 | B10 | K5 | / | A40 | 60 | / | / | B30 | 51 | 196 |
| S8 | B10 | K5 | / | A40 | 70 | / | D10+E5 | C50 | 54 | 244 |
| S9 | B10 | / | / | A40 | 0 | / | / | B30 | 31 | 111 |
| S10 | B10 | / | / | A40 | 10 | / | D20+E5 | A5 | 34 | 124 |
| S11 | B10 | / | / | A40 | 20 | / | / | B30 | 21 | 121 |
| S12 | B10 | / | / | A40 | 30 | / | / | C50 | 9 | 139 |
| S13 | B10 | / | / | A40 | 40 | / | / | B30 | 16 | 136 |
| S14 | B10 | / | / | A40 | 50 | / | / | B30 | 6 | 136 |
| S15 | B10 | / | / | A40 | 60 | / | D20+E5 | A5 | 19 | 159 |
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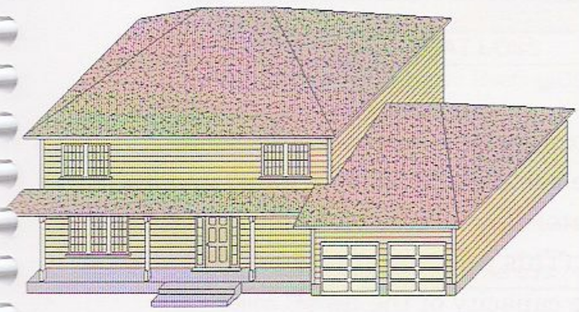
| PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS | | | | | | | | | | page 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| J.1 Trunk Letter/No | A | | | | | | | | B | |
| J.2 Outlet location (Room) | *Kit/ Din* | *Liv* | *Kit/ Din* | *Base* | *Base* | *Liv* | *Ent* | *Base* | *Bed1* | *Bed2* |
| J.3 Outlet No (S) | *S1* | *S2* | *S3* | *S4* | *S5* | *S6* | *S7* | *S8* | *S9* | *S10* |
| J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7) (Heating) | *79* | *63* | *79* | *75* | *75* | *63* | *43* | *75* | *54* | *52* |
| J.4b Outlet flow rate (cfm) (Line D.4 ÷ D.7) (Cooling) | *98* | *99* | *98* | *18* | *18* | *99* | *43* | *18* | *63* | *48* |
| J.5 Outlet size | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* |
| J.6 Outlet pressure loss (in. W.C.) | *0.02* | *0.02* | *0.02* | *0.01* | *0.01* | *0.02* | *0.005* | *0.01* | *0.01* | *0.01* |
| J.7 S/A Plenum pressure (in. W.C.) (Line G.3) | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* |
| J.8 Adjusted duct design pressure (J.7 - J.6) | *0.13* | *0.13* | *0.13* | *0.14* | *0.14* | *0.13* | *0.15* | *0.14* | *0.14* | *0.14* |
| J.9 Branch effective length (ft) (Part I) | *162* | *154* | *165* | *168* | *178* | *186* | *196* | *244* | *111* | *124* |
| J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9] | *0.08* | *0.08* | *0.08* | *0.08* | *0.08* | *0.07* | *0.08* | *0.06* | *0.13* | *0.11* |
| J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5) | *6.5* | *6.5* | *6.5* | *5.5* | *5.5* | *6.5* | *4.5* | *6.0* | *5.0* | *4.5* |
| J.12 Branch rectangular equivalent (Appendix C6) | *12× 3-1/4* | *12× 3-1/4* | *12× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *12× 3-1/4* | *10× 3-1/4* | *12× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* |
| J.13 Trunk flow rate (cfm) accumulation of J.4 | *79* | *142* | *221* | *296* | *371* | *434* | *477* | *552* | *606* | *658* |
| J.13b Trunk flow rate (cfm) accumulation of J.4b | *98* | *197* | *295* | *313* | *331* | *430* | *473* | *491* | *554* | *602* |
| J.14 Lowest loss/100 ft encountered from duct end. | *0.08* | *0.08* | *0.08* | *0.08* | *0.08* | *0.07* | *0.07* | *0.06* | *0.06* | *0.06* |
| J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5) | ——— | ——— | ——— | ——— | ——— | ——— | ——— | *12.5* | ——— | ——— |
| J.16 Trunk rectangular equivalent (Appendix C6) | ——— | ——— | ——— | ——— | ——— | ——— | ——— | *17×8* | ——— | ——— |
| J.17 Installed Trunk size (Transitions) | ——— | ——— | ——— | ——— | ——— | ——— | ——— | *18×8* | ——— | ——— |
| J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | | | | | | *552* | | |

## PART J - CONTINUED

page 8

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1 | B | | | | | | | | | | | | | |
| J.2 | *MBed* | *Bath* | *Base* | *Base* | *MBed* | | | | | | | | | |
| J.3 | *S11* | *S12* | *S13* | *S14* | *S15* | | | | | | | | | |
| J.4 | *52* | *42* | *75* | *75* | *52* | | | | | | | | | |
| J.4b | *69* | *33* | *18* | *18* | *69* | | | | | | | | | |
| J.5 | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | | | | | | | | | |
| J.6 | *0.01* | *0.005* | *0.01* | *0.01* | *0.01* | | | | | | | | | |
| J.7 | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | | | | | | | | | |
| J.8 | *0.14* | *0.15* | *0.14* | *0.14* | *0.14* | | | | | | | | | |
| J.9 | *121* | *139* | *136* | *136* | *159* | | | | | | | | | |
| J.10 | *0.12* | *0.10* | *0.10* | *0.10* | *0.09* | | | | | | | | | |
| J.11 | *5.0* | *4.5* | *5.5* | *5.5* | *5.5* | | | | | | | | | |
| J.12 | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | | | | | | | | | |
| J.13 | *710* | *752* | *827* | *902* | *954* | | | | | | | | | |
| J.13b | *671* | *704* | *722* | *740* | *809* | | | | | | | | | |
| J.14 | *0.06* | *0.06* | *0.06* | *0.06* | *0.06* | | | | | | | | | |
| J.15 | — | — | — | — | *15.5* | | | | | | | | | |
| J.16 | — | — | — | — | *28×8* | | | | | | | | | |
| J.17 | — | — | — | — | *28×8* | | | | | | | | | |
| J.18 | | | | | *613* | | | | | | | | | |

## 4.2 Example # 2 (Kelowna )



*Customer:*

Mr. Smith, 222 London St.,
Kelowna, British Columbia X4X 4X4
Phone and fax

*Location:*

The house is to be constructed in Kelowna, British Columbia. House volume is 47,814 cu. ft. **Re: Page 2 RHLG worksheet.**

*Design Conditions:*

**Note:** Specification sheets for the mechanical equipment required can be found in Appendix A of this manual

*Heating:*

The heating unit will be a DLM Geothermal forced air Unit properly sized for the calculated heat loss including ventilation.

*Cooling:*

The cooling unit will be a DLM Geothermal forced air Unit properly sized for the calculated heat gain including ventilation.

*Air Cleaner:*

The standard filter which comes with the Unit will be not be replaced.

*Duct System:*

The duct system shall conform to the duct layout drawings and floor plans on the following pages.

*Ventilation:*

Customer selects model HRV3-200 to meet 100 CFM ventilation flow rate required and therefore duct system is used for the distribution of ventilation air.

*Floor Registers:*

Customer selects 10 × 4 steel floor registers.

**Note:** As ventilation air is introduced into the duct system, a mixed air temperature calculation is required.

**Note:** Ventilation Heat loss may be reduced by HRV % effectiveness.

## Additional Design information

***System Type:***

This example is a closed ground loop system where water entering temperatures are assumed at 30°F (winter) and 80°F (summer). The system water flow is at a 11.5 gpm for winter and 9.0 gpm for summer. (This information is provided only to show more precisely the capacity of the unit).

***Heating Capacity:***

The heat loss is calculated at 43,917 Btuh + 11,502 Btuh of ventilation giving a total of 55,419 Btuh.

***Unit Selection: (heating)***

Industry practice shows that geothermal unit capacity is selected at no less than 65% of the calculated heat loss. If we assume that the capacity is selected on 65% of capacity then the unit must produce around 36,000 Btu +, around 3 tons. It is also assumed that a 10 kW (34,130 Btuh) electric heater is used for back-up for the few occasions when the unit does not meet the load requirements. It can then be assumed that the 3 ton Geothermal unit plus 10kW back-up meets or exceeds the Total Heat Loss.

***Unit Selection: (cooling)***

The cooling capacity of the 3 ton unit (variable capacity) easily exceeds the 2.5 tons of cooling required.

Note: Designer estimates 0.36" w.c. as sufficient pressure for system design. Designer bases distribution on both heating and cooling.

Note: Designer adjusts available design static pressure in favor of return air system.

**HRAI Residential Heat Loss and Heat Gain Calculations** Page 2

| SECTION B | DESIGN CONDITIONS | | |
|---|---|---|---|
| **HEAT LOSS** | | **HEAT GAIN** | |
| Outdoor Design Temperature Heating(ODT) | 1 °F / ~~°C~~ | Outdoor Design Temperature Cooling (ODT) | 91 °F / ~~°C~~ |
| Indoor Design Temperature (IDT) | 72 °F / ~~°C~~ | Indoor Design Temperature (IDT) | 75 °F / ~~°C~~ |
| Mean Soil Temperature | 52 °F / ~~°C~~ | North Latitude | 49.5 ° |
| | | Summer Mean Daily Temperature Range | 29 °F / ~~°C~~ |
| Building Volume (Vb) | 47814 ft³ / ~~m³~~ | Building Conditioned Area | 5740 ft² / ~~m²~~ |
| HRV Apparent Sensible Effectiveness = | 0.74 | (insert N/A if no HRV/ERV installed) | |

Ventilation System:

- ☐ Case #1: Exhaust Only System
- ☐ Case #2: Direct Ducted System
- ☑ Case #3: Central Forced Air Syst

| SECTION C | ROOM HEAT LOSS / HEAT GAIN SUMMARY | | | | | | |
|---|---|---|---|---|---|---|---|
| Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ | Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ |
| 1 | Basement | 9876 | 2329 | 3 | M Bed | 3396 | 2687 |
| 2 | Dining | 2981 | 2493 | 3 | Bath 1 | 1426 | 1100 |
| 2 | Bath 2 | 1193 | 768 | 3 | Bed 1 | 3287 | 2496 |
| 2 | Utility | 1231 | 597 | 3 | Bed 2 | 2875 | 2142 |
| 2 | Kit/Break | 4398 | 2956 | 3 | Bed 3 | 2441 | 1985 |
| 2 | Family | 4749 | 3187 | 3 | Ensuite | 283 | 149 |
| 2 | Living | 3642 | 3294 | 3 | W.I.C. | 874 | 683 |
| 2 | Ent/Hall | 1265 | 1097 | | | | |
| | | | | | | | |
| | | | | SUB TOTAL | | 43917 Section 18 | 27958 Section 21 |

| SECTION D | BUILDING HEAT LOSS SUMMARY | | | |
|---|---|---|---|---|
| Building Sub Total Heat Loss | (Section 18) | 43917 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Loss | (Section 19) | 11502 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Loss** | (Section 20) | **55419** | Btuh/~~W~~ | |

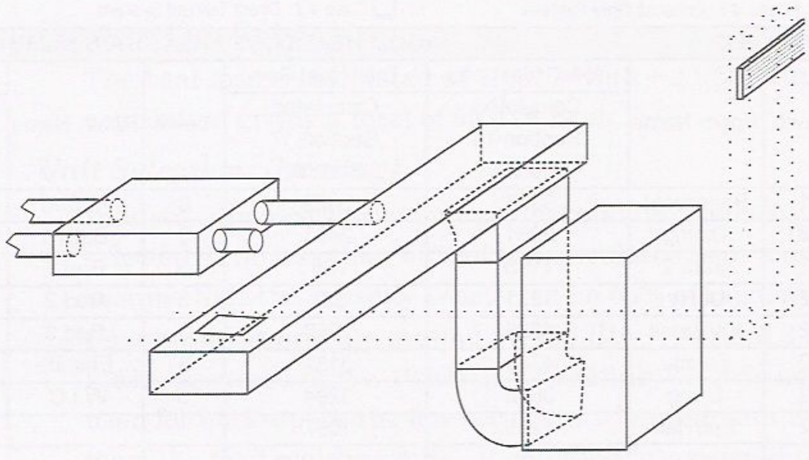
| SECTION E | BUILDING HEAT GAIN SUMMARY | | | |
|---|---|---|---|---|
| Building Sub Total Heat Gain | (Section 21) | 27958 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Gain | (Section 22) | 2592 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Gain** | (Section 23) | **30550** | Btuh/~~W~~ | |

**Notes:**

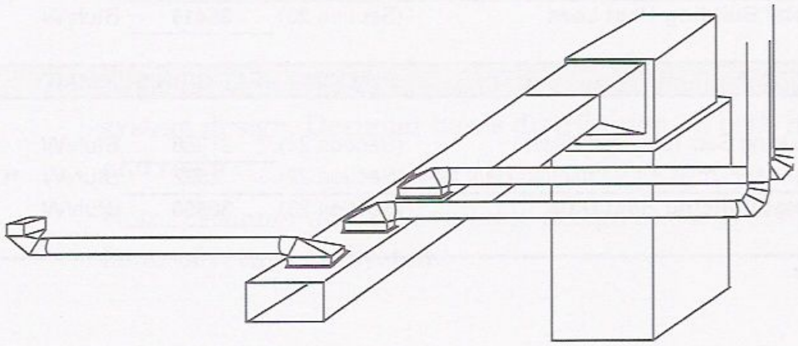
Forms Available From: HRAI, 2350 Matheson Blvd. East, Suite 101
Mississauga, Ontario L4W 5G9 ver. Jul / 2017

**Note**: The following drawings demonstrate the general configuration of the ductwork near the furnace. Although not to scale nor complete in detail, they provide a clear indication of the fittings used and the path the air must follow as it enters and leaves the furnace.

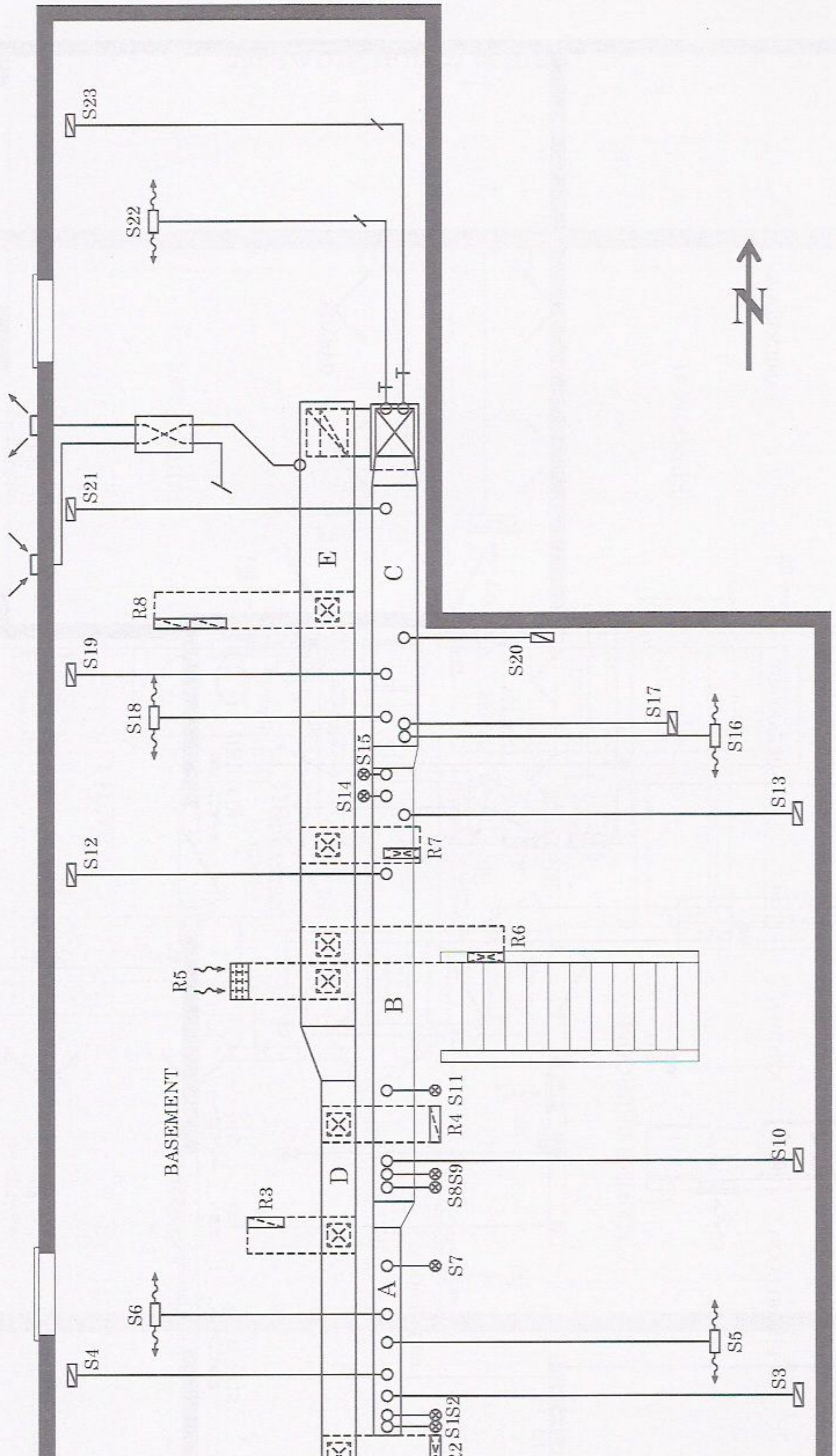
*Return Air*



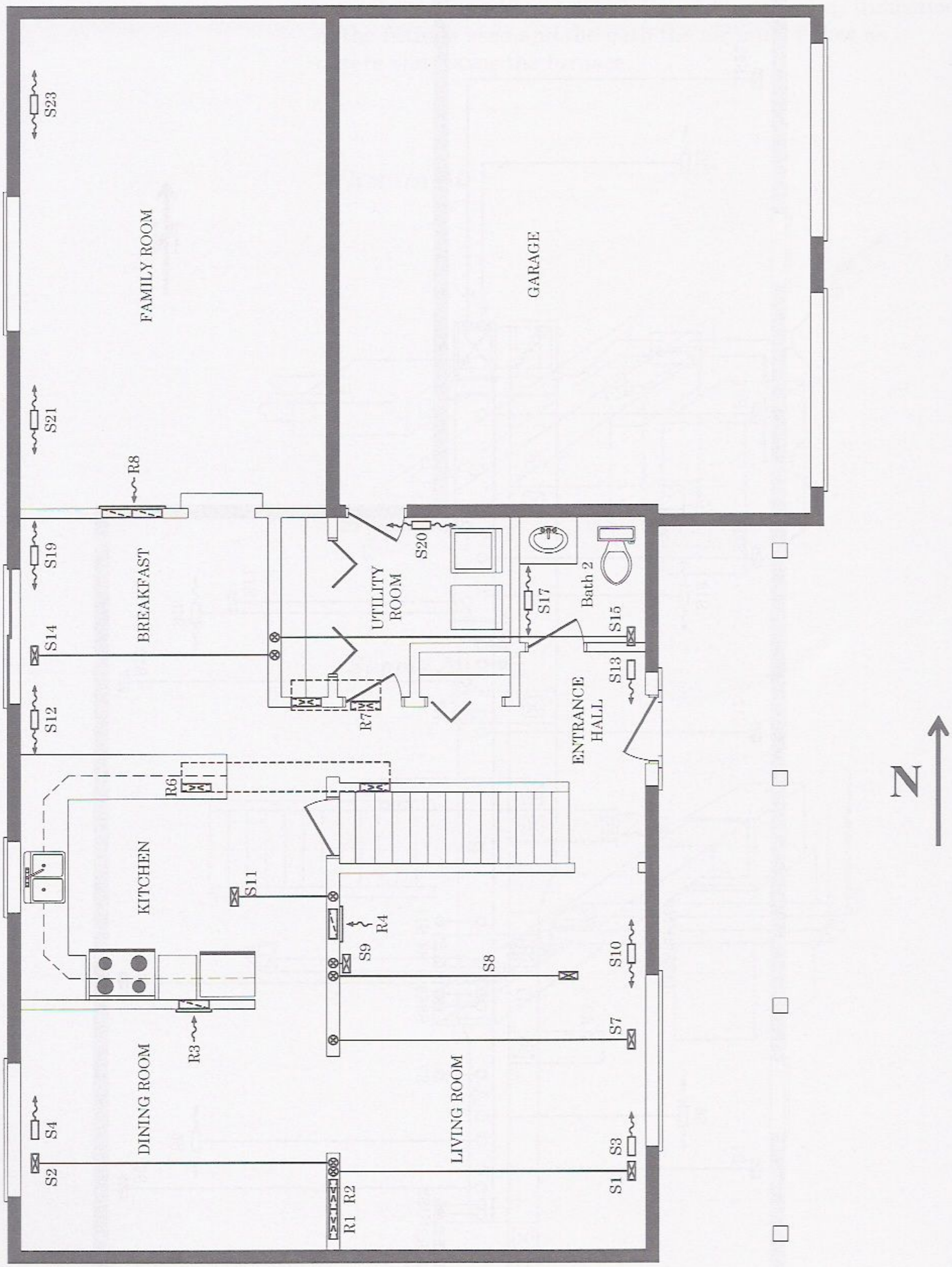
*Supply Air*



## Kelowna (Basement), Drawing not to scale

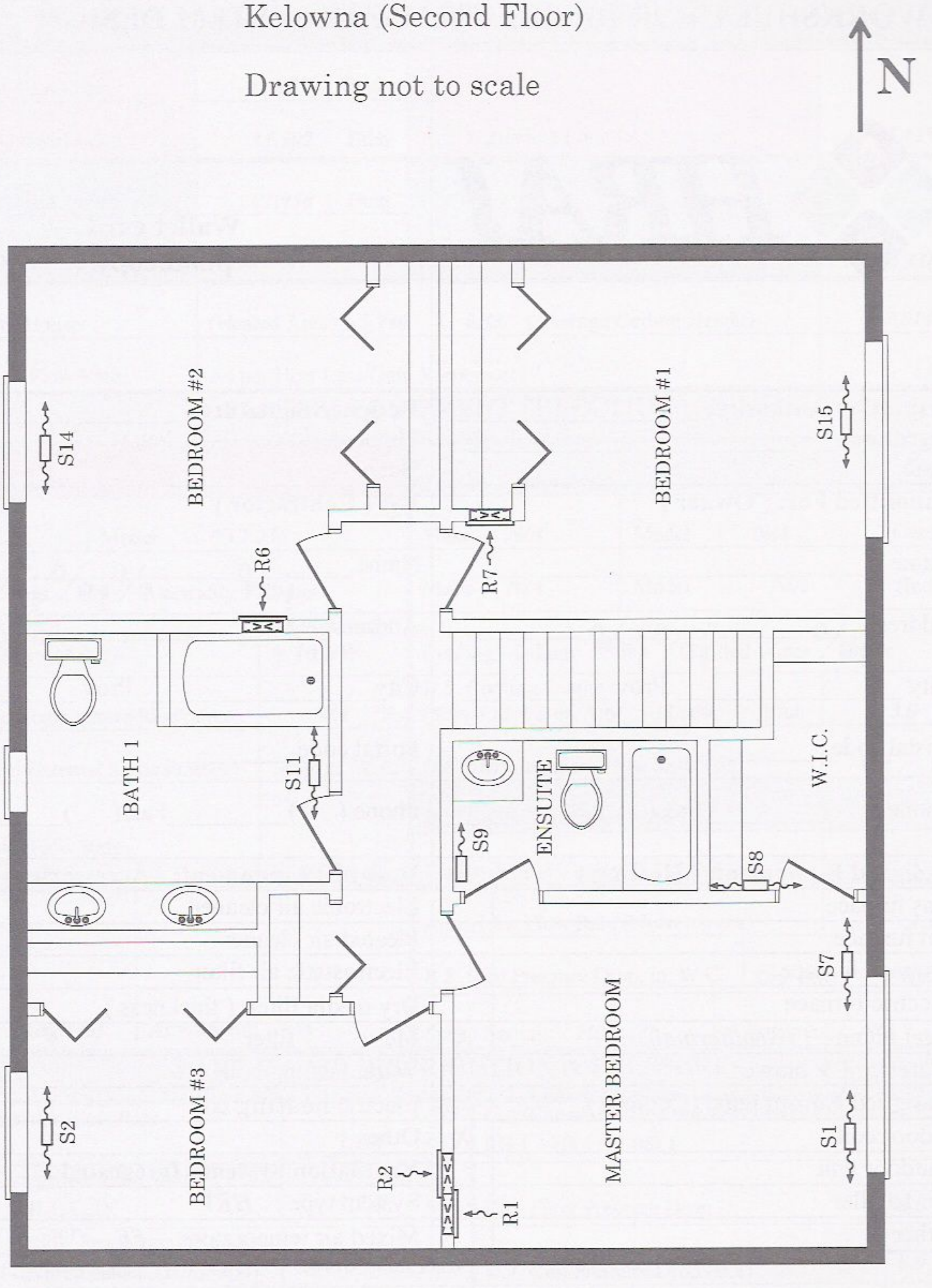


Kelowna (Main Floor), Drawing not to scale



Kelowna (Second Floor)

Drawing not to scale



## WORKSHEET FOR RESIDENTIAL AIR SYSTEM DESIGN page 1

| HRAI YOUR ENVIRONMENT OUR EXPERTISE | **Wallet card photocopy** |
|---|---|
| **Inspection Authority:** ____________<br>Signature: ____________<br>Date: / / | **Designer/Signature:** ____________<br>Phone: ( )________ Fax ( )________<br>Date: / / |
| **Submitted For: ( Owner )**<br>Name ____________<br>Address ____________<br>City ________ Prov ________<br>Postal code________<br>Phone ( )________ Fax ( )________ | **By: ( Contractor )**<br>Name ____________<br>Address ____________<br>City ________ Prov ________<br>Postal code ________<br>Phone ( )________ Fax ( )________ |

| **Designed Equipment: ( Heating )** | | **Designed Equipment: ( Accessories )** | |
|---|---|---|---|
| Gas furnace | | Electronic air cleaner | |
| Oil furnace | | Pleated air cleaner | |
| Propane furnace | | Electrostatic air filter | |
| Electric furnace | | Dry media filter ( thickness ) " | |
| Heat pump *(Geothermal)* | *X* | Merv ____ filter | |
| Water coil & blower | | Water heating coil | |
| **Designed Equipment: (Cooling )** | | Electric heating coil | |
| Indoor coil | *X* | Other | |
| Outdoor unit | | **Ventilation System ( Integrated )** | *X* |
| Air handler | | System type : *HRV* | *X* |
| Other | | Mixed air temperature __*66*__ °F | |

Forms available from: HRAI * 2350 Matheson Blvd East * Suite 101 * Mississauga, Ontario * L4W 5G9

## PART A - DESIGN LOAD SPECIFICATIONS

page 2

| | | | |
|---|---|---|---|
| A.1 Sub Total Heat Loss | *43,917* Btuh. | A.3 Total Heat Loss (A.1 + A.2) | *55,419* Btuh. |
| A.2 Ventilation Heat Loss | *11,502* Btuh. | | |
| A.4 Sub Total Heat Gain | *27,958* Btuh. | A.6 Total Heat Gain (A.4 + A.5) | *30,550* Btuh. |
| A.5 Ventilation Heat Gain | *2,592* Btuh. | | |
| A.7 Volume of House: | (Heated Area) *5,740* X *8.33'* (Average Ceiling Height) | | *47,814* cu ft. |
| A.8 Ventilation Flow Rate: | As per Heat Loss/Gain Worksheet | | *150* cfm. |

## PART B – EQUIPMENT SELECTION

| Heating Equipment: | |
|---|---|
| Make *DLM* | Model *NVV036* |
| Fuel Type: Gas Oil Electricity Other | |
| B.1 Heating Output (Minimum 100% - of A.3) | *36,000* Btuh. *+ 10 kW* |
| B.2 Approved Temperature Rise/range | *N/A* °F. |
| B.3 Equipment External Static Pressure | *0.50* in. W.C. |
| B.4 Heating Air Flow Rate (blower specs) | *1,220* cfm |
| Speed setting: *High (8)* | Adjustment: *N/A* |

| Cooling Equipment: | | |
|---|---|---|
| Make *N/A* | Model *N/A* | (Outdoor Unit) |
| Make *N/A* | Model *N/A* | (Indoor Unit) |
| Cooling Medium: DX Chilled Water Other | | |
| B.5 Cooling Output (80% - 125% of A.6) *38,000* Btuh | *3.0* Tons | |
| B.6 Manufacturers Flow Rate/Ton | *400* (cfm/ton) | |
| B.7 Cooling Air Flow Rate. | | |
| Target Air Flow rate = B.5 X B.6 | *1,200* cfm | |
| Actual Air Flow Rate (blower specs) | *1,220* cfm | |
| B.8 Coil Pressure Drop, in. W.C. | Dry *0.0* | Wet *0.0* |
| Speed Setting: *High (8)* | Adjustment: *N/A* | |

## PART C – AIR DISTRIBUTION & PRESSURE

| | | | |
|---|---|---|---|
| C.1 Circulation Air Flow Rate ( A.7 x 0.025 ) | *1,195* cfm | C.5 Calculated Heating Temperature Rise [ B.1 ÷ (B.4 x 1.08) ] | *27.3* °F |
| C.2 System Design Air Flow Rate (highest of B.4, B.7, C.1) | *1,220* cfm | C.6 Filter Pressure Drop | *0.0* in. W.C. |
| C.3 Cooling Airflow Proportioning Factor Calculate to 4 decimal places (B.7 ÷ A.4) | *.0436* cfm/Btuh | C.7 Coil Pressure Drop (B.8) | *0.0* in. W.C. |
| C.4 Heating Airflow Proportioning Factor Calculate to 4 decimal places (C.2 ÷ A.1) or (B.4 ÷ A.1) | *.0278* cfm/Btuh | C.8 Total of Pressure Drop (C.6 + C.7) | *0.0* in. W.C. |
| | | C.9 Available Design Pressure (B.3 C.8) or Selected Design Pressure | *.36* in. W.C. |

**Note:** When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

| PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES | | | | | | | | page 3 |
|---|---|---|---|---|---|---|---|---|
| D.1 Floor | **Second floor** | | | | | | | |
| D.2 Room | *M/Bed* | *Bath 1* | *Bed #1* | *Bed #2* | *Bed #3* | *Ensuite* | *W.I.C.* | |
| D.3 Cooling load (Btuh) | *2,686* | *1,100* | *2,496* | *2,142* | *1,985* | *149* | *683* | |
| D.4 Room cooling flow rate (D.3 x C.3) | *117* | *48* | *109* | *93* | *87* | *7* | *30* | |
| D.5 Heating load (Btuh) | *3,396* | *1,426* | *3,287* | *2,875* | *2,441* | *283* | *874* | |
| D.6 Room heating flow rate (D.5 x C.4) | *94* | *40* | *91* | *80* | *68* | *8* | *24* | |
| D.7 Number of outlets per room | *2* | *1* | *1* | *1* | *1* | *1* | *1* | |
| D.8 Floor supply air flow rates (greatest airflow heating or cooling) | *heating 405/cooling 491* | | | | | | | |

| PART D - CONTINUED | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| D.1 | **Main Floor** | | | | | | | **Basement** | | |
| D.2 | *Din* | *Liv* | *Kit/Brk* | *Family* | *Utility* | *Bath 2* | *Ent/Hall* | *Base* | | |
| D.3 | *2,493* | *3,294* | *2,956* | *3,187* | *597* | *768* | *1,097* | *2,329* | | |
| D.4 | *109* | *144* | *129* | *139* | *26* | *34* | *48* | *102* | | |
| D.5 | *2,981* | *3,642* | *4,398* | *4,749* | *1,231* | *1,193* | *1,265* | *9,876* | | |
| D.6 | *83* | *101* | *122* | *132* | *34* | *33* | *35* | *275* | | |
| D.7 | *1* | *2* | *2* | *2* | *1* | *1* | *1* | *5* | | |
| D.8 | *heating 540 cooling/ 629* | | | | | | | *heating 275/ cooling102* | | |

| PART E - INLET FLOW RATES | | | | | |
|---|---|---|---|---|---|
| Floor level (Location) | Basement (50% D.8 Max) | 1st floor (Sum of D.8 Min) | 2nd floor (Sum of D.8 Min) | 3rd floor (Sum of D.8 Min) | Total = ( C.2 ) (System cfm) |
| E.1 Floor return air flow rate | *138/* | *540/629* | *(405 + 137)/491* | *N/A* | *1,220* |
| E.2 Minimum number of openings | *1* | *4+* | *4+* | *N/A* | |
| E.3 Actual number of openings | *1* | *4* | *4* | *N/A* | |
| E.4 Actual cfm per opening ( E.1 ÷ E.3 ) | *138/102* | *135/157* | *136/123* | *N/A* | |

**Note:** After location of supply outlets and return inlets are determined, produce preliminary drawing.

## PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS page 4

| Inlet No | Equipment Connection (Group 1) | Trunk To Drop Connection (Group 1) | Trunk Transitions (Group 2) | Trunk Fittings (Group 2) | Duct To Joist (Group 3) | Turbulence Effect | Stud To Joist (Group 4) | Grille Opening To Stud (Group 4) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| R1 | C10 | B35 | K15 | / | A¹25 | 120 | A15 | D10 | 60 | 290 |
| R2 | C10 | B35 | K15 | / | A²60 | 80 | A15 | D10 | 59 | 284 |
| R3 | C10 | B35 | K15 | / | A²60 | 40 | B25 | D10 | 40 | 235 |
| R4 | C10 | B35 | K15 | / | A²60 | 0 | A15 | D10 | 36 | 181 |
| R5 | C10 | B35 | / | / | A²60 | 160 | / | C10 | 31 | 306 |
| R6 | C10 | B35 | / | / | A²60 | 120 | 3-B25 75 | D10 | 52 | 362 |
| R7 | C10 | B35 | / | / | A²60 | 80 | 3-B25 75 | D10 | 40 | 310 |
| R8 | C10 | B35 | / | / | A²60 | 40 | B25 | D10 | 20 | 200 |
| | | | | | | | | | | |
| | | | | | | | | | | |

## PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length __*362*__ ft).

G.2 **R/A Plenum Pressure:**
Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

( *0.36* ) x ( *0.55* ) = __*0.20*__ in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**
Available Design pressure (Line C.9) - R/A Plenum Pressure

( *0.36* ) - ( *0.20* ) = __*0.16*__ in. W.C. (Record Line J.7)

## PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS page 5

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H.1 Trunk Letter/No | *D* | | | | *E* | | | | | |
| H.2 Inlet Location (Room) | *M/Bed* | *Bed 3* | *Din* | *Liv* | *Base* | *Bed 2* | *Bed 1* | *Family* | | |
| H.3 Inlet No (R) | *R1* | *R2* | *R3* | *R4* | *R5* | *R6* | *R7* | *R8* | | |
| H.4 Inlet flow rate (cfm) (Line E.4 adjusted) | *136* | *136* | *157* | *157* | *138* | *136* | *136* | *314* | | |
| H.5 Minimum required inlet free area (sq. in.) (Appendix C8) | *50* | *50* | *58* | *58* | *50* | *50* | *50* | *115* | | |
| H.6 Inlet size (Appendix A) | *10×6* | *10×6* | *12×6* | *12×6* | *10×6* | *10×6* | *10×6* | *20×8* | | |
| H.7 Inlet Pressure Loss (in. W.C.) | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | *0.02* | | |
| H.8 R/A Plenum pressure (in. W.C.) (Line G.2) | *0.20* | *0.20* | *0.20* | *0.20* | *0.20* | *0.20* | *0.20* | *0.20* | | |
| H.9 Adjusted duct design pressure (H.8 - H.7) | *0.18* | *0.18* | *0.18* | *0.18* | *0.18* | *0.18* | *0.18* | *0.18* | | |
| H.10 Branch effective length (ft) (Part F) | *290* | *284* | *235* | *181* | *306* | *362* | *310* | *200* | | |
| H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10] | *0.06* | *0.06* | *0.08* | *0.10* | *0.06* | *0.05* | *0.06* | *0.09* | | |
| H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5) | *7.5* | *7.5* | *7.5* | *7.5* | *7.0* | *7.5* | *7.5* | *9.0/ 2-7.0* | | |
| H.13 Branch rectangular equivalent (Appendix C6) | *14× 3-1/4* | *14× 3-1/4* | *14× 3-1/4* | *14× 3-1/4* | *14× 3-1/4* | *14× 3-1/4* | *14× 3-1/4* | *2 - 14× 3-1/4* | | |
| H.14 Joist to trunk opening size (2 x area H.13) | *10×9* | *10×9* | *10×9* | *10×9* | *10×9* | *10×9* | *10×9* | *2 - 10×9* | | |
| H.15 Trunk flow rate (cfm) accumulation of H.4 | — | — | — | *586* | — | — | — | *1,222* | | |
| H.16 Lowest loss/100 ft encountered from duct end. | *0.06* | *0.06* | *0.06* | *0.06* | *0.06* | *0.05* | *0.05* | *0.05* | | |
| H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5) | — | — | — | *12.5* | — | — | — | *17.5* | | |
| H.18 Trunk rectangular equivalent (Appendix C6) | — | — | — | *17×8* | — | — | — | *27×10* | | |
| H.19 Installed Trunk size (Transitions) | — | — | — | *17×8* | — | — | — | *27×10* | | |
| H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | | *620* | | | | *652* | | |

## PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

| Outlet No | Plenum Fitting (Group 5) | Trunk Transition (Group 6) | Trunk Fittings (Group 6) | Trunk To Branch Take offs (Group 7) | Aspiration Effect | Duct Flex Length (ft) | Branch Elbows (Group 8) | Boot Fitting (Group 8) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| S1 | B10 | 2-K/10 | / | A40 | 0 | / | 2-D/20 | B30 | 61 | 171 |
| S2 | B10 | 2-K/10 | / | A40 | 10 | / | 2-D/20 | B30 | 61 | 181 |
| S3 | B10 | 2-K/10 | / | A40 | 20 | / | / | B30 | 50 | 160 |
| S4 | B10 | 2-K/10 | / | A40 | 30 | / | / | B30 | 45 | 165 |
| S5 | B10 | 2-K/10 | / | A40 | 40 | / | / | B30 | 45 | 175 |
| S6 | B10 | 2-K/10 | / | A40 | 50 | / | / | B30 | 40 | 180 |
| S7 | B10 | 2-K/10 | / | A40 | 60 | / | 2-D/20 | B30 | 55 | 225 |
| S8 | B10 | K5 | / | A40 | 0 | / | 2-D/20 | C50 | 49 | 174 |
| S9 | B10 | K5 | / | A40 | 10 | / | 2-D/20 | B30 | 40 | 155 |
| S10 | B10 | K5 | / | A40 | 20 | / | / | B30 | 41 | 146 |
| S11 | B10 | K5 | / | A40 | 30 | / | 2-D/20 | B30 | 40 | 175 |
| S12 | B10 | K5 | / | A40 | 40 | / | / | B30 | 27 | 152 |
| S13 | B10 | K5 | / | A40 | 50 | / | / | B30 | 27 | 162 |
| S14 | B10 | K5 | / | A40 | 60 | / | 2-D/20 | B30 | 35 | 200 |
| S15 | B10 | K5 | / | A40 | 70 | / | 2-D/20 | B30 | 39 | 214 |
| S16 | B10 | / | / | A40 | 0 | / | / | B30 | 22 | 102 |
| S17 | B10 | / | / | A40 | 10 | / | / | B30 | 20 | 110 |
| S18 | B10 | / | / | A40 | 20 | / | / | B30 | 18 | 118 |
| S19 | B10 | / | / | A40 | 30 | / | / | B30 | 19 | 129 |
| S20 | B10 | / | / | A40 | 40 | / | / | C50 | 17 | 157 |
| S21 | B10 | / | / | A40 | 50 | / | / | B30 | 13 | 143 |
| S22 | C10 | / | / | / | 0 | / | D10+E5 | B30 | 15 | 70 |
| S23 | C10 | / | / | / | 0 | / | D10+E5 | B30 | 22 | 77 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

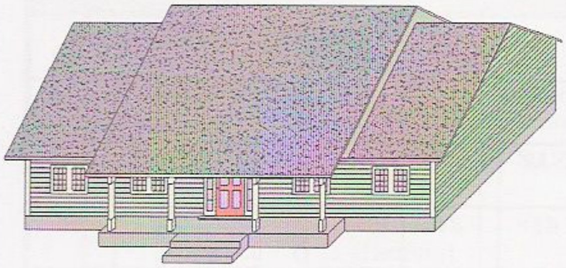
| PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS | | | | | | | page 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| J.1 Trunk Letter/No | A | | | | | | | B | | |
| J.2 Outlet location (Room) | M/Bed | Bed 3 | Liv | Din | Base | Base | M/Bed | W.I.C. | En-suite | Liv |
| J.3 Outlet No (S) | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
| J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7) (Heating) | 47 | 68 | 51 | 83 | 55 | 55 | 47 | 24 | 8 | 51 |
| J.4b Outlet flow rate (cfm) (Line D.4 ÷ D.7) (Cooling) | 59 | 87 | 72 | 109 | 20 | 20 | 59 | 30 | 7 | 72 |
| J.5 Outlet size | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 | 10×4 |
| J.6 Outlet pressure loss (in. W.C.) | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| J.7 S/A Plenum pressure (in. W.C.) (Line G.3) | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| J.8 Adjusted duct design pressure (J.7 - J.6) | 0.15 | 0.15 | 0.15 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| J.9 Branch effective length (ft) (Part I) | 171 | 181 | 160 | 165 | 175 | 180 | 225 | 174 | 155 | 146 |
| J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9] | 0.09 | 0.08 | 0.09 | 0.09 | 0.09 | 0.08 | 0.07 | 0.09 | 0.10 | 0.10 |
| J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5) | 5.0 | 6.0 | 5.0 | 6.0 | 5.0 | 5.0 | 5.0 | 4.0 | 4.0 | 5.0 |
| J.12 Branch rectangular equivalent (Appendix C6) | 10× 3-1/4 | 12× 3-1/4 | 10× 3-1/4 | 12× 3-1/4 | 10× 3-1/4 | 10× 3-1/4 | 10× 3-1/4 | 10× 3-1/4 | 10× 3-1/4 | 10× 3-1/4 |
| J.13 Trunk flow rate (cfm) accumulation of J.4 | ____ | ____ | ____ | ____ | ____ | ____ | 406 | ____ | ____ | ____ |
| J.13b Trunk flow rate (cfm) accumulation of J.4b | ____ | ____ | ____ | ____ | ____ | ____ | 426 | ____ | ____ | ____ |
| J.14 Lowest loss/100 ft encountered from duct end. | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 |
| J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5) | ____ | ____ | ____ | ____ | ____ | ____ | 11.0 | ____ | ____ | ____ |
| J.16 Trunk rectangular equivalent (Appendix C6) | ____ | ____ | ____ | ____ | ____ | ____ | 13x8 | ____ | ____ | ____ |
| J.17 Installed Trunk size (Transitions) | ____ | ____ | ____ | ____ | ____ | ____ | 13x8 | ____ | ____ | ____ |
| J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | | | | | 590 | | | |

## PART J - CONTINUED

page 8

| J.1 | B | | | | | C | | | | | | | Plenum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.2 | *Bath1* | *Break /kit* | *Ent/ Hall* | *Bed 2* | *Bed1* | *Base* | *Bath 2* | *Base* | *Break /kit* | *Util* | *Fam* | | *Base* | *Fam* |
| J.3 | *S11* | *S12* | *S13* | *S14* | *S15* | *S16* | *S17* | *S18* | *S19* | *S20* | *S21* | | *S22* | *S23* |
| J.4 | *40* | *61* | *35* | *80* | *91* | *55* | *33* | *55* | *61* | *34* | *66* | | *55* | *66* |
| J.4b | *48* | *65* | *48* | *93* | *109* | *20* | *34* | *20* | *65* | *26* | *70* | | *20* | *70* |
| J.5 | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | *10×4* | | *10×4* | *10×4* |
| J.6 | *0.01* | *0.01* | *0.01* | *0.02* | *0.02* | *0.01* | *0.01* | *0.01* | *0.01* | *0.01* | *0.01* | | *0.01* | *0.01* |
| J.7 | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | *0.16* | | *0.16* | *0.16* |
| J.8 | *0.15* | *0.15* | *0.15* | *0.15* | *0.14* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | *0.15* | | *0.15* | *0.15* |
| J.9 | *175* | *152* | *162* | *200* | *214* | *102* | *110* | *118* | *129* | *157* | *143* | | *70* | *77* |
| J.10 | *0.09* | *0.10* | *0.09* | *0.08* | *0.07* | *0.15* | *0.14* | *0.13* | *0.12* | *0.10* | *0.10* | | *0.21* | *0.19* |
| J.11 | *4.0* | *5.0* | *4.0* | *6.0* | *6.0* | *4.0* | *4.0* | *5.0* | *5.0* | *4.0* | *5.0* | | *4.0* | *5.0* |
| J.12 | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *12× 3-1/4* | *12× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | *10× 3-1/4* | | *10× 3-1/4* | *10× 3-1/4* |
| J.13 | | | | | *796* | | | | | | *1100* | | / | / |
| J.13b | | | | | *898* | | | | | | *1133* | | / | / |
| J.14 | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | *0.07* | | / | / |
| J.15 | | | | | *14.5* | | | | | | *15.5* | | / | / |
| J.16 | | | | | *24×8* | | | | | | *28×8* | | / | / |
| J.17 | | | | | *24×8* | | | | | | *28×8* | | / | / |
| J.18 | | | | | *674* | | | | | | *728* | | / | / |

## 4.3 Example # 3 (Weyburn)



***Customer:***

Mr. Smith, 24 Main St.,

Weyburn, Saskatchewan X4X 4X4

Phone and fax

***Location:***

The house is to be constructed in Weyburn, Saskatchewan. House volume is 29,546 cu. ft. **Re: Page 2 RHLG worksheet.**

***Design Conditions:***

**Note:** Specification sheets for the mechanical equipment required can be found in Appendix A of this manual

***Heating:***

The choice of heating unit will be at the discretion of the instructor. This will allow a heating unit selection that represents the most popular regarding location and fuel availability.

***Cooling:***

The choice of cooling unit will be at the discretion of the instructor.

***Air Cleaner:***

The standard filter which comes with the heating unit will be replaced with a DLM Merv 10 air cleaner.

***Duct System:***

The duct system shall conform to the duct layout drawings and floor plans on the following pages.

***Ventilation:***

The choice of the ventilation system is to be at the discretion of the instructor.

Owner requests 4" × 10" steel registers.

| HRAI Residential Heat Loss and Heat Gain Calculations | | | | Page 2 |
|---|---|---|---|---|
| **SECTION B** | **DESIGN CONDITIONS** | | | |

| HEAT LOSS | | | HEAT GAIN | | |
|---|---|---|---|---|---|
| Outdoor Design Temperature Heating(ODT) | -27 | °F / ~~°C~~ | Outdoor Design Temperature Cooling (ODT) | 90 | °F / ~~°C~~ |
| Indoor Design Temperature (IDT) | 72 | °F / ~~°C~~ | Indoor Design Temperature (IDT) | 75 | °F / ~~°C~~ |
| Mean Soil Temperature | 43 | °F / ~~°C~~ | North Latitude | 49.5 | ° |
| | | | Summer Mean Daily Temperature Range | 27 | °F / ~~°C~~ |
| Building Volume (Vb) | 29546 | $ft^3$ / ~~$m^3$~~ | Building Conditioned Area | 3476 | $ft^2$ / ~~$m^2$~~ |

HRV Apparent Sensible Effectiveness = (insert N/A if no HRV/ERV installed)

Ventilation System:

☐ Case #1: Exhaust Only System ☐ Case #2: Direct Ducted System ☐ Case #3: Central Forced Air Syst

**SECTION C** **ROOM HEAT LOSS / HEAT GAIN SUMMARY**

| Level | Room Name | Total Heat Loss<br>Calculated Section 16 Btuh/~~W~~ | Total Heat Gain<br>Calculated Section 17 Btuh/~~W~~ | Level | Room Name | Total Heat Loss<br>Calculated Section 16 Btuh/~~W~~ | Total Heat Gain<br>Calculated Section 17 Btuh/~~W~~ |
|---|---|---|---|---|---|---|---|
| 1 | Basement | 15734 | 3295 | | | | |
| 2 | Living | 5769 | 3771 | | | | |
| 2 | Din/Kit | 7892 | 5172 | | | | |
| 2 | Foyer | 1859 | 1486 | | | | |
| 2 | M Bed | 4575 | 3072 | | | | |
| 2 | Bed 1 | 2887 | 2196 | | | | |
| 2 | Bed 2 | 3859 | 2542 | | | | |
| 2 | Bath | 1797 | 1230 | | | | |
| | | | | | | | |
| | | | | **SUB TOTAL** | | 44372<br>**Section 18** | 22764<br>**Section 21** |

**SECTION D** **BUILDING HEAT LOSS SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Loss | (Section 18) | 44372 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Loss | (Section 19) | 10692 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Loss** | (Section 20) | **55064** | Btuh/~~W~~ | |

**SECTION E** **BUILDING HEAT GAIN SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Gain | (Section 21) | 22764 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Gain | (Section 22) | 1620 | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Gain** | (Section 23) | **24384** | Btuh/~~W~~ | |

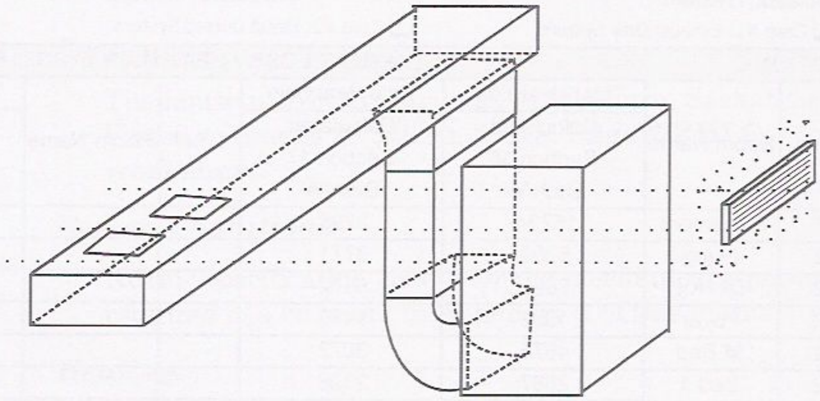
**Notes:**

Forms Available From: HRAI, 2350 Matheson Blvd. East, Suite 101
Mississauga, Ontario L4W 5G9

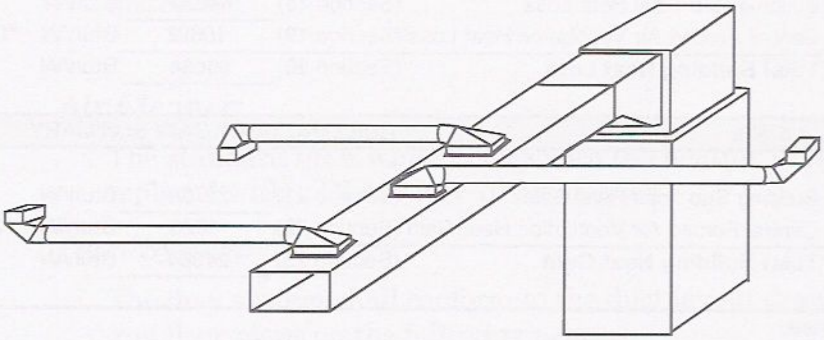
ver. Jul / 2017

**Note**: The following drawings demonstrate the general configuration of the ductwork near the furnace. Although not to scale nor complete in detail, they provide a clear indication of the fittings used and the path the air must follow as it enters and leaves the furnace.

*Return Air*

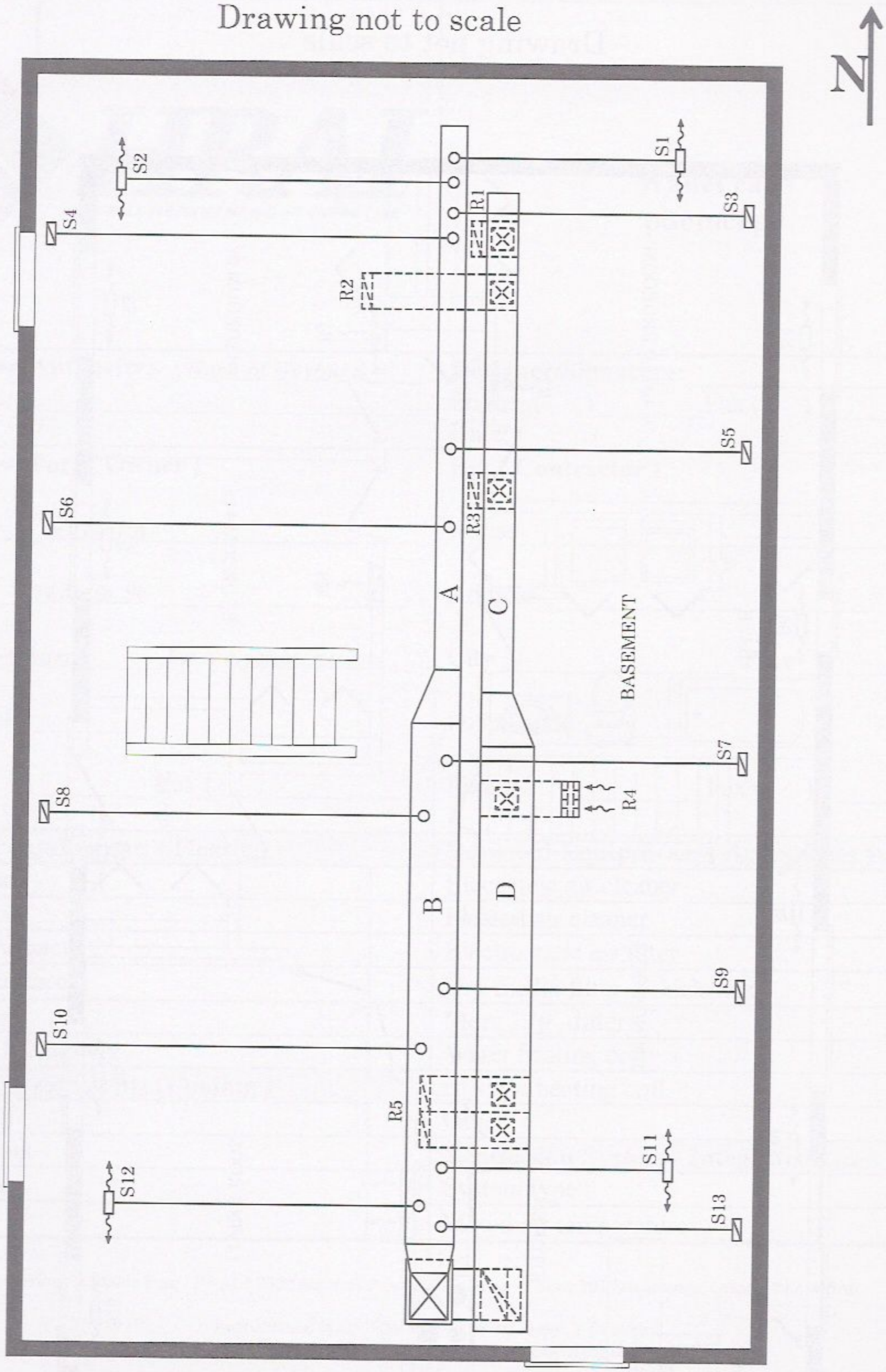


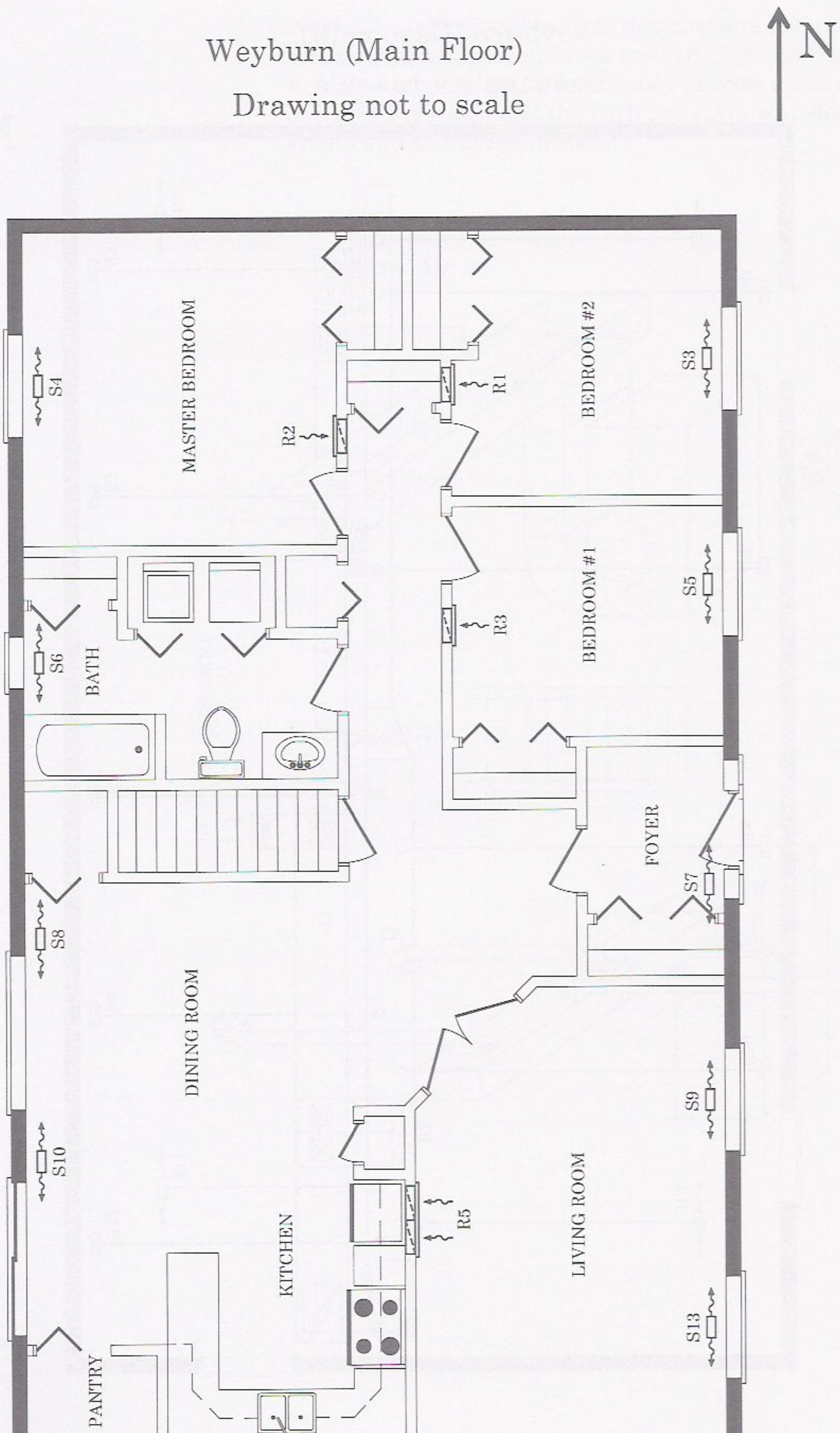
*Supply Air*



Weyburn (Basement)

Drawing not to scale





N
Weyburn (Main Floor)
Drawing not to scale
MASTER BEDROOM
BEDROOM #2
BEDROOM #1
BATH
FOYER
DINING ROOM
LIVING ROOM
KITCHEN
PANTRY
S3
S4
S5
S6
S7
S8
S9
S10
S13
R1
R2
R3
R5

## WORKSHEET FOR RESIDENTIAL AIR SYSTEM DESIGN page 1

| HRAI YOUR ENVIRONMENT OUR EXPERTISE | Wallet card photocopy |
|---|---|
| **Inspection Authority:** Town of Weyburn<br>Signature: ______<br>Date: / / | **Designer/Signature:** ______<br>Phone: ( )______ Fax ( )______<br>Date: / / |
| **Submitted For: ( Owner )**<br>Name Mr Smith<br>Address 24 Main St<br>City Weyburn Prov Saskatchewan<br>Postal code______<br>Phone ( )______ Fax ( )______ | **By: ( Contractor )**<br>Name ______<br>Address ______<br>City ______ Prov ______<br>Postal code ______<br>Phone ( )______ Fax ( )______ |

| **Designed Equipment: ( Heating )** | | **Designed Equipment: ( Accessories )** | |
|---|---|---|---|
| Gas furnace | | Electronic air cleaner | |
| Oil furnace | | Pleated air cleaner | |
| Propane furnace | | Electrostatic air filter | |
| Electric furnace | | Dry media filter ( thickness ) ″ | |
| Heat pump | | Merv 10 filter | |
| Water coil & blower | | Water heating coil | |
| **Designed Equipment: (Cooling )** | | Electric heating coil | |
| Indoor coil | | Other | |
| Outdoor unit | | **Ventilation System ( Integrated )** | |
| Air handler | | System type : | |
| Other | | Mixed air temperature ______ °F | |

Forms available from: HRAI * 2800 Skymark Avenue * Building 1* Suite 201 Mississauga, Ontario * L4W 5A6

## PART A - DESIGN LOAD SPECIFICATIONS page 2

| | | | |
|---|---|---|---|
| A.1 Sub Total Heat Loss | *44,372* Btuh. | | |
| A.2 Ventilation Heat Loss | *10,692* Btuh. | A.3 Total Heat Loss (A.1 + A.2) | *55,064* Btuh. |
| A.4 Sub Total Heat Gain | *22,764* Btuh. | | |
| A.5 Ventilation Heat Gain | *1,620* Btuh. | A.6 Total Heat Gain (A.4 + A.5) | *24,384* Btuh. |
| A.7 Volume of House: | (Heated Area) 3,476 X *8.5′* (Average Ceiling Height) | | *29,546* cu ft. |
| A.8 Ventilation Flow Rate: | As per Heat Loss/Gain Worksheet | | *100* cfm. |

## PART B – EQUIPMENT SELECTION

| | | | |
|---|---|---|---|
| Heating Equipment: | | Cooling Equipment: | |
| Make | Model | Make | Model (Outdoor Unit) |
| Fuel Type: Gas Oil Electricity Other | | Make | Model (Indoor Unit) |
| B.1 Heating Output (Minimum 100% - of A.3) | Btuh. | Cooling Medium: DX Chilled Water Other | |
| B.2 Approved Temperature Rise/range | °F. | B.5 Cooling Output (80% - 125% of A.6) Btuh | Tons |
| B.3 Equipment External Static Pressure | in. W.C. | B.6 Manufacturers Flow Rate/Ton | (cfm/ton) |
| B.4 Heating Air Flow Rate (blower specs) | cfm | B.7 Cooling Air Flow Rate. | |
| | | Target Air Flow rate = B.5 X B.6 | cfm |
| | | Actual Air Flow Rate (blower specs) | cfm |
| | | B.8 Coil Pressure Drop, in. W.C. | Dry / Wet |
| Speed setting: | Adjustment: | Speed Setting: | Adjustment: |

## PART C – AIR DISTRIBUTION & PRESSURE

| | | | |
|---|---|---|---|
| C.1 Circulation Air Flow Rate ( A.7 x 0.025 ) | cfm | C.5 Calculated Heating Temperature Rise [ B.1 ÷ (B.4 x 1.08) ] | °F |
| C.2 System Design Air Flow Rate (highest of B.4, B.7, C.1) | cfm | C.6 Filter Pressure Drop | in. W.C. |
| C.3 Cooling Airflow Proportioning Factor Calculate to 4 decimal places (B.7 ÷ A.4) | cfm/Btuh | C.7 Coil Pressure Drop (B.8) | in. W.C. |
| C.4 Heating Airflow Proportioning Factor Calculate to 4 decimal places (C.2 ÷ A.1) or (B.4 ÷ A.1) | cfm/Btuh | C.8 Total of Pressure Drop (C.6 + C.7) | in. W.C. |
| | | C.9 Available Design Pressure (B.3 C.8) or Selected Design Pressure | in. W.C. |

**Note:** When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

| PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES | | | | | | | | page 3 |
|---|---|---|---|---|---|---|---|---|
| D.1 Floor | *Main Floor* | | | | | | | |
| D.2 Room | *M/Bed* | *Bath* | *Bed #1* | *Bed #2* | *Foyer* | *Din/Kit* | *Liv* | |
| D.3 Cooling load (Btuh) | *3,072* | *1,230* | *2,196* | *2,542* | *1,486* | *5,172* | *3,771* | |
| D.4 Room cooling flow rate (D.3 x C.3) | | | | | | | | |
| D.5 Heating load (Btuh) | *4,575* | *1,797* | *2,887* | *3,859* | *1,859* | *7,892* | *5,769* | |
| D.6 Room heating flow rate (D.5 x C.4) | | | | | | | | |
| D.7 Number of outlets per room | | | | | | | | |
| D.8 Floor supply air flow rates (greatest airflow heating or cooling) | | | | | | | | |

| PART D - CONTINUED | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| D.1 | *Basement* | | | | | | | | | | |
| D.2 | | | | | | | | | | | |
| D.3 | *3,295* | | | | | | | | | | |
| D.4 | | | | | | | | | | | |
| D.5 | *15,734* | | | | | | | | | | |
| D.6 | | | | | | | | | | | |
| D.7 | | | | | | | | | | | |
| D.8 | | | | | | | | | | | |

| PART E - INLET FLOW RATES | | | | | |
|---|---|---|---|---|---|
| Floor level (Location) | Basement (50% D.8 Max) | 1st floor (Sum of D.8 Min) | 2nd floor (Sum of D.8 Min) | 3rd floor (Sum of D.8 Min) | Total = ( C.2 ) (System cfm) |
| E.1 Floor return air flow rate | | | | | |
| E.2 Minimum number of openings | | | | | |
| E.3 Actual number of openings | | | | | |
| E.4 Actual cfm per opening ( E.1 ÷ E.3 ) | | | | | |

**Note:** After location of supply outlets and return inlets are determined, produce preliminary drawing.

## PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS page 4

| Inlet No | Equipment Connection (Group 1) | Trunk To Drop Connection (Group 1) | Trunk Transitions (Group 2) | Trunk Fittings (Group 2) | Duct To Joist (Group 3) | Turbulence Effect | Stud To Joist (Group 4) | Grille Opening To Stud (Group 4) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| *R1* | | | | | | | | | *46* | |
| *R2* | | | | | | | | | *49* | |
| *R3* | | | | | | | | | *37* | |
| *R4* | | | | | | | | | *28* | |
| *R5* | | | | | | | | | *17* | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

## PART G - DUCT DESIGN PRESSURE

G.1 (Return Branch Longest Effective Length _______ ft).

G.2 **R/A Plenum Pressure:**
Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

( ) x ( ) = __________ in. W.C. (Record Line H.8)

G.3 **S/A Plenum Pressure:**
Available Design pressure (Line C.9) - R/A Plenum Pressure

( ) - ( ) = _________ in. W.C. (Record Line J.7)

## PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS page 5

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H.1 Trunk Letter/No | *C* | | | *D* | | | | | | |
| H.2 Inlet Location (Room) | *Bed 2* | *M/Bed* | *Bed 1* | *Base* | *Liv* | | | | | |
| H.3 Inlet No (R) | *R1* | *R2* | *R3* | *R4* | *R5* | | | | | |
| H.4 Inlet flow rate (cfm) (Line E.4 adjusted) | | | | | | | | | | |
| H.5 Minimum required inlet free area (sq. in.) (Appendix C8) | | | | | | | | | | |
| H.6 Inlet size (Appendix A) | | | | | | | | | | |
| H.7 Inlet Pressure Loss (in. W.C.) | | | | | | | | | | |
| H.8 R/A Plenum pressure (in. W.C.) (Line G.2) | | | | | | | | | | |
| H.9 Adjusted duct design pressure (H.8 - H.7) | | | | | | | | | | |
| H.10 Branch effective length (ft) (Part F) | | | | | | | | | | |
| H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10] | | | | | | | | | | |
| H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5) | | | | | | | | | | |
| H.13 Branch rectangular equivalent (Appendix C6) | | | | | | | | | | |
| H.14 Joist to trunk opening size (2 x area H.13) | | | | | | | | | | |
| H.15 Trunk flow rate (cfm) accumulation of H.4 | | | | | | | | | | |
| H.16 Lowest loss/100 ft encountered from duct end. | | | | | | | | | | |
| H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5) | | | | | | | | | | |
| H.18 Trunk rectangular equivalent (Appendix C6) | | | | | | | | | | |
| H.19 Installed Trunk size (Transitions) | | | | | | | | | | |
| H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | | | | | | | | |

## PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

| Outlet No | Plenum Fitting (Group 5) | Trunk Transition (Group 6) | Trunk Fittings (Group 6) | Trunk To Branch Take offs (Group 7) | Aspiration Effect | Duct Flex Length (ft) | Branch Elbows (Group 8) | Boot Fitting (Group 8) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| S1 | | | | | | | | | 48 | |
| S2 | | | | | | | | | 50 | |
| S3 | | | | | | | | | 48 | |
| S4 | | | | | | | | | 51 | |
| S5 | | | | | | | | | 39 | |
| S6 | | | | | | | | | 41 | |
| S7 | | | | | | | | | 28 | |
| S8 | | | | | | | | | 29 | |
| S9 | | | | | | | | | 20 | |
| S10 | | | | | | | | | 21 | |
| S11 | | | | | | | | | 11 | |
| S12 | | | | | | | | | 13 | |
| S13 | | | | | | | | | 11 | |

| PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS | | | | | | | | | | page 7 |
|---|---|---|---|---|---|---|---|---|---|---|
| J.1 Trunk Letter/No | A | | | | | | B | | | |
| J.2 Outlet location (Room) | Base | Base | Bed 2 | M/Bed | Bed 1 | Bath | Foyer | Din/ Kit | Liv | Din/ Kit |
| J.3 Outlet No (S) | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 |
| J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7) (Heating) | | | | | | | | | | |
| J.4b Outlet flow rate (cfm) (Line D.4 ÷ D.7) (Cooling) | | | | | | | | | | |
| J.5 Outlet size | | | | | | | | | | |
| J.6 Outlet pressure loss (in. W.C.) | | | | | | | | | | |
| J.7 S/A Plenum pressure (in. W.C.) (Line G.3) | | | | | | | | | | |
| J.8 Adjusted duct design pressure (J.7 - J.6) | | | | | | | | | | |
| J.9 Branch effective length (ft) (Part I) | | | | | | | | | | |
| J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9] | | | | | | | | | | |
| J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5) | | | | | | | | | | |
| J.12 Branch rectangular equivalent (Appendix C6) | | | | | | | | | | |
| J.13 Trunk flow rate (cfm) accumulation of J.4 | | | | | | | | | | |
| J.13b Trunk flow rate (cfm) accumulation of J.4b | | | | | | | | | | |
| J.14 Lowest loss/100 ft encountered from duct end. | | | | | | | | | | |
| J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5) | | | | | | | | | | |
| J.16 Trunk rectangular equivalent (Appendix C6) | | | | | | | | | | |
| J.17 Installed Trunk size (Transitions) | | | | | | | | | | |
| J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | | | | | | | | |

## PART J - CONTINUED

page 8

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1 | *B* | | | | | | | | | | | | | |
| J.2 | *Base* | *Base* | *Liv* | | | | | | | | | | | |
| J.3 | *S11* | *S12* | *S13* | | | | | | | | | | | |
| J.4 | | | | | | | | | | | | | | |
| J.4b | | | | | | | | | | | | | | |
| J.5 | | | | | | | | | | | | | | |
| J.6 | | | | | | | | | | | | | | |
| J.7 | | | | | | | | | | | | | | |
| J.8 | | | | | | | | | | | | | | |
| J.9 | | | | | | | | | | | | | | |
| J.10 | | | | | | | | | | | | | | |
| J.11 | | | | | | | | | | | | | | |
| J.12 | | | | | | | | | | | | | | |
| J.13 | | | | | | | | | | | | | | |
| J.13b | | | | | | | | | | | | | | |
| J.14 | | | | | | | | | | | | | | |
| J.15 | | | | | | | | | | | | | | |
| J.16 | | | | | | | | | | | | | | |
| J.17 | | | | | | | | | | | | | | |
| J.18 | | | | | | | | | | | | | | |

# APPENDIX A
# EQUIPMENT SPECIFICATIONS



NOTE: The specifications included in this section are generic in nature and although they are representative of actual equipment, they may vary considerably from specific pieces of equipment experienced in the field.

**For actual field calculations, Manufacturer's specifications for the equipment to be installed must be used.**

# D L MANUFACTURING

## GAS FURNACE SPECIFICATIONS
## (Variable Capacity)


### Model Identification Number

**SL P 98 UH 070 V 36 B**

Unit Type
SL = Signature Collection

Stages
P = Precise Comfort Technology

AFUE
98 = 98%

Configuration
UH = Up-flow/Horizontal

Nominal Gas Input
070 = 66,000 Btuh
090 = 88,000 Btuh
110 = 106,000 Btuh
135 = 132,000 Btuh

Blower
V = Variable Speed

Nominal add-on Cooling Capacity
36 = 2.0 – 3.5 tons
48 = 4.0 tons
60 = 4.0 – 5.0 tons

Cabinet Width
B = 17-1/2 in
C = 21.0 in
D = 24-1/2 in

## Unit Specifications

| Model No | SLP98UH070V36 | SLP98UH090V36 | SLP98UH090V48 |
|---|---|---|---|
| AFUE | 97.0% | 98.0% | 97.5% |
| Maximum Input - Btuh | 66,000 | 88,000 | 88,000 |
| Maximum Output - Btuh | 64,000 | 85,000 | 85,000 |
| Temperature rise range - °F | 50 - 80 | 60 - 90 | 50 - 80 |
| Minimum Input - Btuh | 23,000 | 31,000 | 31,000 |
| Minimum Output - Btuh | 22,000 | 30,000 | 30,000 |
| Temperature rise range - °F | 35 - 65 | 35 - 65 | 35 - 65 |
| High Static - in w.g. | 0.8 | 0.8 | 0.8 |
| Air Volume range - cfm | 339 - 1365 | 520 - 1360 | 528 - 1770 |
| Motor Output HP | 1/2 | 1/2 | 1/2 |
| Tons of add-on cooling | 2.0 - 3.0 | 2.0 - 3.5 | 2.5 - 4.0 |

| Model No | SLP98UH090V60 | SLP98UH110V60 | SLP98UH135V60 |
|---|---|---|---|
| AFUE | 98.2% | 97.5% | 97.5% |
| Maximum Input - Btuh | 88,000 | 110,000 | 132,000 |
| Maximum Output - Btuh | 85,000 | 106,000 | 126,000 |
| Temperature rise range - °F | 50 - 80 | 50 - 80 | 55 - 85 |
| Minimum Input - Btuh | 31,000 | 39,000 | 46,000 |
| Minimum Output - Btuh | 30,000 | 38,000 | 45,000 |
| Temperature rise range - °F | 35 - 65 | 35 - 65 | 35 - 65 |
| High Static - in w.g. | 0.8 | 0.8 | 0.8 |
| Air Volume range - cfm | 375 - 2195 | 554 - 2125 | 634 - 2190 |
| Motor Output HP | 1.0 | 1.0 | 1.0 |
| Tons of add-on cooling | 3.0 - 5.0 | 3.0 - 5.0 | 3.5 - 5.0 |

Notes:

- Furnace filter not furnished, must be field provided, see cabinet specifications for filter size.
- Motor speeds may be field adjusted up to 15% above and below factory default values.
- Variable capacity within minimum and maximum input (control type dependent)

**Blower Specifications (filter pressure drop not included):**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SL98PUH070V36 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 484 | 531 | 625 | 718 | 812 | 906 | 999 | 1093 |
| Increase (+7.5%) | 446 | 490 | 579 | 667 | 756 | 845 | 933 | 1022 |
| Default Heat cfm | 407 | 449 | 533 | 616 | 700 | 784 | 867 | 951 |
| Decrease (-7.5%) | 377 | 413 | 487 | 561 | 635 | 709 | 783 | 857 |
| Decrease (-15%) | 346 | 378 | 442 | 506 | 571 | 635 | 699 | 763 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 590 | 705 | 805 | 955 | 840 | 1050 | 1205 | 1355 |
| Default cfm | 540 | 640 | 725 | 820 | 750 | 945 | 1130 | 1230 |
| - 10% cfm | 500 | 580 | 665 | 720 | 685 | 805 | 990 | 1110 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SLP98UH090V36 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 657 | 702 | 792 | 881 | 971 | 1061 | 1150 | 1240 |
| Increase (+7.5%) | 631 | 673 | 757 | 841 | 926 | 1010 | 1094 | 1178 |
| Default Heat cfm | 605 | 644 | 723 | 802 | 880 | 959 | 1037 | 1116 |
| Decrease (-7.5%) | 574 | 608 | 676 | 745 | 814 | 882 | 951 | 1020 |
| Decrease (-15%) | 542 | 571 | 630 | 689 | 747 | 806 | 864 | 923 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 610 | 705 | 795 | 920 | 840 | 1015 | 1165 | 1300 |
| Default cfm | 560 | 640 | 715 | 810 | 770 | 910 | 1050 | 1190 |
| - 10% cfm | 525 | 605 | 665 | 725 | 695 | 795 | 945 | 1110 |

## Blower Specifications (continued)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SLP98UH090V48 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 747 | 812 | 943 | 1073 | 1204 | 1334 | 1465 | 1595 |
| Increase (+7.5%) | 698 | 759 | 882 | 1005 | 1127 | 1250 | 1372 | 1495 |
| Default Heat cfm | 649 | 706 | 821 | 936 | 1051 | 1165 | 1280 | 1395 |
| Decrease (-7.5%) | 589 | 644 | 755 | 867 | 978 | 1089 | 1200 | 1312 |
| Decrease (-15%) | 528 | 582 | 690 | 797 | 905 | 1013 | 1120 | 1228 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 820 | 1005 | 1135 | 1290 | 1140 | 1340 | 1525 | 1725 |
| Default cfm | 755 | 880 | 1025 | 1150 | 1040 | 1235 | 1395 | 1565 |
| - 10% cfm | 680 | 815 | 925 | 1065 | 910 | 1120 | 1275 | 1400 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SLP98UH090V60 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 609 | 684 | 835 | 986 | 1136 | 1287 | 1437 | 1588 |
| Increase (+7.5%) | 551 | 623 | 769 | 914 | 1059 | 1205 | 1350 | 1496 |
| Default Heat cfm | 492 | 562 | 702 | 842 | 983 | 1123 | 1263 | 1403 |
| Decrease (-7.5%) | 436 | 502 | 633 | 765 | 896 | 1028 | 1159 | 1291 |
| Decrease (-15%) | 380 | 441 | 564 | 687 | 810 | 932 | 1055 | 1178 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 1040 | 1225 | 1380 | 1550 | 1555 | 1715 | 1920 | 2135 |
| Default cfm | 960 | 1085 | 1225 | 1415 | 1430 | 1565 | 1790 | 1980 |
| - 10% cfm | 840 | 990 | 1085 | 1250 | 1280 | 1450 | 1580 | 1790 |

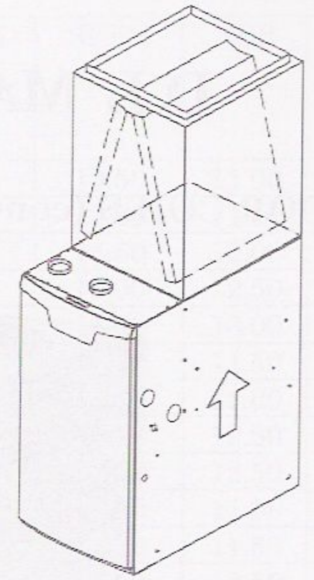
## Blower Specifications (continued)

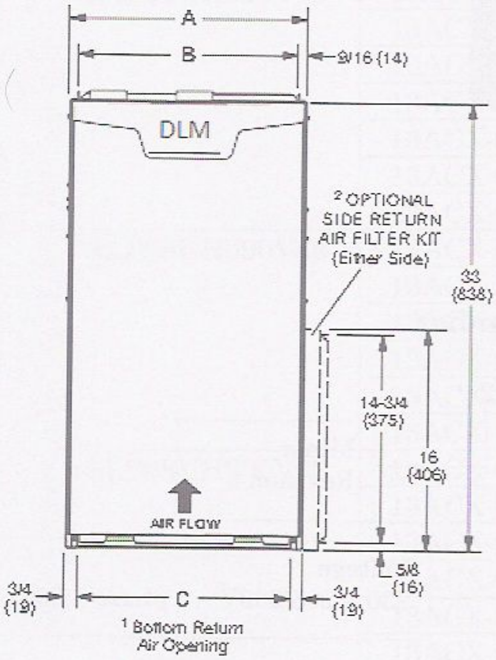
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SLP98UH110V60 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 733 | 825 | 1009 | 1194 | 1378 | 1562 | 1747 | 1931 |
| Increase (+7.5%) | 708 | 794 | 967 | 1139 | 1312 | 1484 | 1657 | 1829 |
| Default Heat cfm | 683 | 763 | 924 | 1085 | 1245 | 1406 | 1566 | 1727 |
| Decrease (-7.5%) | 632 | 707 | 857 | 1007 | 1157 | 1307 | 1457 | 1608 |
| Decrease (-15%) | 580 | 650 | 790 | 929 | 1069 | 1209 | 1348 | 1488 |
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 1050 | 1195 | 1315 | 1495 | 1515 | 1710 | 1870 | 2065 |
| Default cfm | 960 | 1095 | 1220 | 1355 | 1360 | 1555 | 1755 | 1890 |
| - 10% cfm | 850 | 985 | 1095 | 1220 | 1215 | 1400 | 1555 | 1755 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model No | SLP98UH135V60 | | | | | | | |
| Return air location | Side | | | | | | | |
| External Static Pressure range | 0.0 – 0.8 in w.c. | | | | | | | |
| Motor Type | ECM | | | | | | | |
| Heating Adjust cfm selections | Heating Input Range and Blower Volume - cfm | | | | | | | |
| | 35% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| Increase (+15%) | 927 | 1010 | 1175 | 1340 | 1505 | 1671 | 1836 | 2001 |
| Increase (+7.5%) | 844 | 923 | 1081 | 1239 | 1398 | 1556 | 1714 | 1873 |
| Default Heat cfm | 760 | 836 | 987 | 1138 | 1290 | 1441 | 1593 | 1744 |
| Decrease (-7.5%) | 703 | 775 | 919 | 1064 | 1208 | 1352 | 1496 | 1641 |
| Decrease (-15%) | 646 | 715 | 852 | 989 | 989 | 1263 | 1400 | 1537 |
| Cooling Blower Performance | 0.0 – 1.0 in w.c. ESP | | | | | | | |
| Cooling Adjust cfm selections | First Stage Cooling Speed | | | | Second Stage Cooling Speed | | | |
| | Low | Medium Low | Medium High | High default | Low | Medium Low | Medium High | High default |
| + 10% cfm | 1070 | 1235 | 1385 | 1535 | 1550 | 1720 | 1925 | 2005 |
| Default cfm | 985 | 1110 | 1245 | 1415 | 1415 | 1605 | 1755 | 1970 |
| - 10% cfm | 870 | 1010 | 1110 | 1280 | 1280 | 1435 | 1610 | 1755 |

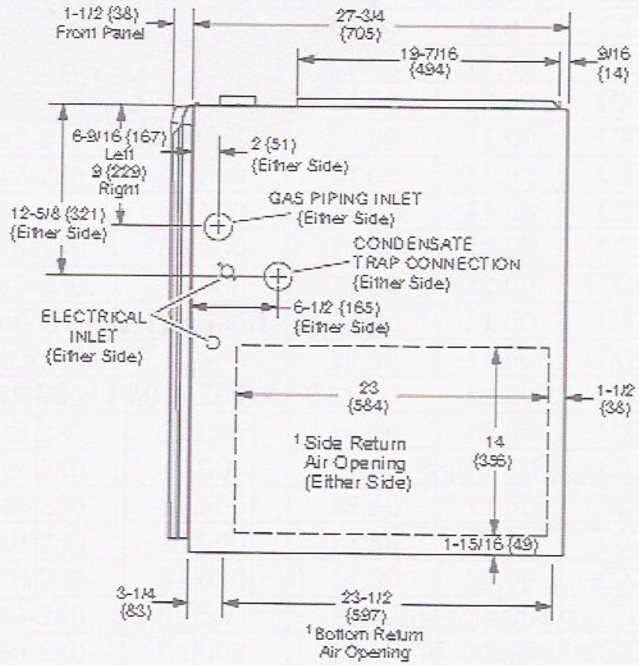
## Furnace Cabinet Specifications:

Note:
Return Air Filter =
25" x 16" (all models)






FRONT VIEW

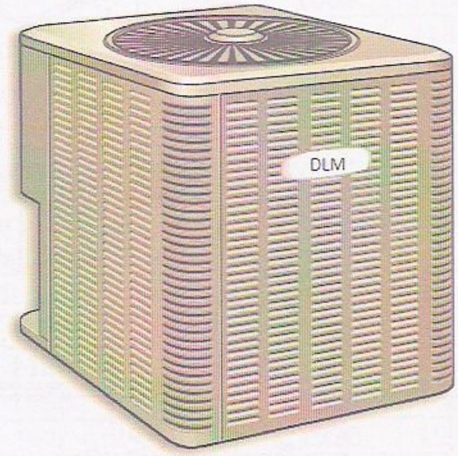



SIDE VIEW

| Model No. | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|
| | in. | mm | in. | mm | in. | mm | in. | mm |
| SLP98UH070V36B | 17-1/2 | 446 | 16-3/8 | 416 | 16 | 406 | 7-5/8 | 194 |
| SLP98UH090V36C<br>SLP98UH090V48C<br>SLP98UH090V60C<br>SLP98UH110V60C | 21 | 533 | 19-7/8 | 505 | 19-1/2 | 495 | 9-3/8 | 238 |
| SLP98UH135V60D | 24-1/2 | 622 | 23-3/8 | 594 | 23 | 584 | 11-1/8 | 283 |

# D L MANUFACTURING

## OUTDOOR COILS (condenser) R-410A SPECIFICATIONS




### Model Identification Number

**13 AC X – 024 – 230 – 2**

Nominal SEER

Unit Type
AC = Air Conditioner
2nd stage at 70% capacity

Refrigerant
X = R410A

Minor Revision #

Voltage
230 = 208/230V – 1 phase – 60hz

Nominal Cooling Capacity
018 = 1.5 tons
024 = 2.0 tons
030 = 2.5 tons
036 = 3.0 tons
042 = 3.5 tons
048 = 4.0 tons
060 = 5.0 tons

## Unit Specifications (Condenser):

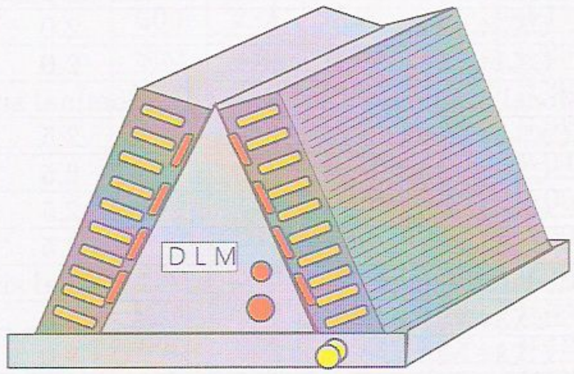
| Furnace model | Matching Condenser coil model numbers | Nominal Capacity Btuh | SEER | EER | Matching Evaporator coil number |
|---|---|---|---|---|---|
| SLP98UH070V36 | 13ACX-018-230 | 18,600 | 13.50 | 11.00 | CX34 - 25 |
| | 13ACX-018-230 | 18,900 | 13.00 | 11.50 | CX34 - 31 |
| | 13ACX-024-230 | 23,200 | 14.50 | 12.00 | CX34 - 18/24 |
| | 13ACX-024-230 | 24,000 | 15.00 | 12.50 | CX34 - 36 |
| | 13ACX-024-230 | 24,600 | 15.50 | 13.00 | CX34 - 38 |
| | 13ACX-030-230 | 28,200 | 13.50 | 11.50 | CX34 - 18/24 |
| | 13ACX-030-230 | 29,000 | 14.00 | 12.00 | CX34 - 30 |
| | 13ACX-030-230 | 30,200 | 14.50 | 12.50 | CX34 - 25 |
| | 13ACX-030-230 | 31,200 | 15.00 | 12.50 | CX34 - 43 |
| | 13ACX-036-230 | 34,600 | 13.50 | 11.00 | CX34 - 31 |
| | 13ACX-036-230 | 35,200 | 14.00 | 11.50 | CX34 - 43 |
| SLP98UH090V36 | 13ACX-030-230 | 30,000 | 14.50 | 12.50 | CX34 - 36 |
| | 13ACX-030-230 | 31,200 | 15.50 | 13.00 | CX34 - 43 |
| | 13ACX-036-230 | 34,200 | 14.00 | 11.50 | CX34 - 36 |
| | 13ACX-036-230 | 35,400 | 14.00 | 12.00 | CX34 - 43 |
| | 13ACX-042-230 | 40,500 | 13.00 | 11.00 | CX34 - 38 |
| | 13ACX-042-230 | 41,000 | 14.00 | 11.50 | CX34 - 43 |
| | 13ACX-042-230 | 41,500 | 14.00 | 11.50 | CX34 - 49 |
| SLP98UH090V48 | 13ACX-036-230 | 35,200 | 14.50 | 12.00 | CX34 - 43 |
| | 13ACX-036-230 | 35,000 | 14.00 | 12.00 | CX34-50/60 |
| | 13ACX-042-230 | 41,000 | 14.00 | 11.50 | CX34 - 43 |
| | 13ACX-042-230 | 41,000 | 13.50 | 11.50 | CX34-50/60 |
| | 13ACX-048-230 | 49.500 | 13.50 | 12.00 | CX34 - 43 |
| | 13ACX-048-230 | 51,000 | 14.00 | 12.50 | CX34 - 62 |
| SLP98UH090V60 | 13ACX-042-230 | 41,500 | 14.00 | 11.50 | CX34 - 43 |
| | 13ACX-042-230 | 41,500 | 13.50 | 11.50 | CX34-50/60 |
| | 13ACX-048-230 | 49,500 | 13.50 | 12.00 | CX34 - 43 |
| | 13ACX-048-230 | 51,000 | 14.00 | 12.00 | CX34 - 62 |
| | 13ACX-060-230 | 59,500 | 13.00 | 11.00 | CX34 - 49 |
| | 13ACX-060-230 | 61,000 | 13.00 | 11.00 | CX34 - 62 |
| SLP98UH110V60 | 13ACX-036-230 | 35,800 | 14.50 | 12.00 | CX34 - 43 |
| | 13ACX-036-230 | 35,400 | 14.50 | 12.00 | CX34-50/60 |
| | 13ACX-042-230 | 41,500 | 14.00 | 11.50 | CX34 - 43 |
| | 13ACX-042-230 | 41,000 | 13.50 | 11.50 | CX34-50/60 |
| | 13ACX-048-230 | 49,500 | 13.50 | 12.00 | CX34 - 43 |
| | 13ACX-048-230 | 51,500 | 14.00 | 12.00 | CX34 - 62 |
| | 13ACX-060-230 | 59,500 | 13.00 | 11.00 | CX34 - 49 |
| | 13ACX-060-230 | 60,500 | 13.50 | 11.00 | CX34 - 62 |

## Unit Specifications (Condenser): continued

| Furnace model | Matching Condenser coil model numbers | Capacity Btuh | SEER | EER | Matching Evaporator coil number |
|---|---|---|---|---|---|
| SLP98UH135V60 | 13ACX-048-230 | 50,500 | 14.00 | 12.00 | CX34 - 60 |
| | 13ACX-048-230 | 51,000 | 14.00 | 12.00 | CX34 - 62 |
| | 13ACX-060-230 | 59,500 | 13.00 | 11.00 | CX34 - 60 |
| | 13ACX-060-230 | 60,500 | 13.50 | 11.50 | CX34 - 62 |

# D L MANUFACTURING

## INDOOR COILS (evaporator) SPECIFICATIONS




### Model Identification Number

**C X 34 – 42 – 6 U**

Unit Type
C = Indoor Coil
Up-flow

Refrigerant Type
X = R-410A

Series

Nominal Cooling Capacity
18/24 = 1.5/2.0 tons
30/31 = 2.5 tons
36/38 = 3.0 tons
42/44 = 3.5 tons
48/49 = 4.0 tons
50/60 = 4.0/5.0 tons
60 = 5.0 tons
62 = 5.0 + tons

Metering Device
6 = Factory installed expansion valve

Cabinet
U = Uncased

## Unit (coil) Specifications (for DLM furnace only)

| Model number | Nominal size (tons) |
|---|---|
| CX34 - 19 | 1.5 |
| CX34 - 25 | 1.5 |
| CX34 - 31 | 1.5 |
| CX34 - 18/24 | 1.5/2.0 |
| CX34 - 36 | 2.0 |
| CX34 - 38 | 2.0 |
| Model number | Nominal size |
| CX34 - 18/24 | 2.5 |
| CX34 - 30 | 2.5 |
| CX34 - 25 | 2.5 |
| CX34 - 43 | 2.5 |
| Model number | Nominal size |
| CX34 - 31 | 3.0 |
| CX34 - 43 | 3.0 |
| CX34 - 36 | 3.0 |
| CX34 - 38 | 3.0 |
| CX34 - 50/60 | 3.0 |
| Model number | Nominal size |
| CX34 - 38 | 3.5 |
| CX34 - 43 | 3.5 |
| CX34 - 49 | 3.5 |
| CX34 - 50/60 | 3.5 |
| Model number | Nominal size |
| CX34 - 43 | 4.0 |
| CX34 - 62 | 4.0 |
| Model number | Nominal size |
| CX34 - 49 | 5.0 |
| CX34 - 60 | 5.0 |
| CX34 - 62 | 5.0 |

## Unit Specifications-coil pressure drop

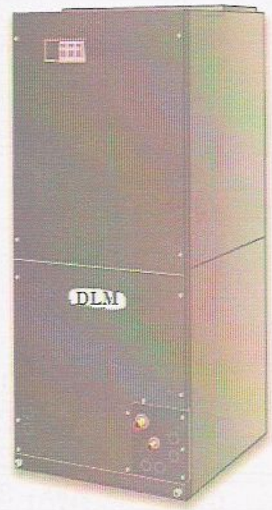
| Model No | Air Volume | | Dry Coil | | Wet Coil | |
|---|---|---|---|---|---|---|
| | cfm | L/s | In. w.g. | pa | In. w.g. | pa |
| CX34 - 18/24 | 400 | 190 | 0.06 | 15 | 0.08 | 20 |
| | 600 | 285 | 0.11 | 27 | 0.17 | 42 |
| | 800 | 380 | 0.18 | 45 | 0.25 | 62 |
| | 1000 | 470 | 0.27 | 67 | 0.39 | 97 |
| | 1200 | 565 | 0.37 | 92 | 0.52 | 129 |
| CX34 - 19 | 200 | 99 | 0.01 | 2 | 0.04 | 10 |
| | 400 | 190 | 0.03 | 7 | 0.05 | 12 |
| | 600 | 285 | 0.08 | 20 | 0.09 | 22 |
| | 800 | 380 | 0.13 | 32 | 0.16 | 40 |
| | 1000 | 470 | 0.20 | 50 | 0.24 | 60 |
| CX34 - 30 | 600 | 285 | 0.09 | 22 | 0.12 | 30 |
| | 800 | 380 | 0.14 | 35 | 0.21 | 52 |
| | 1000 | 470 | 0.22 | 55 | 0.30 | 75 |
| | 1200 | 565 | 0.30 | 75 | 0.43 | 107 |
| | 1400 | 650 | 0.40 | 99 | 0.55 | 137 |
| CX34 - 25 | 600 | 285 | 0.04 | 10 | 0.07 | 17 |
| | 800 | 380 | 0.09 | 22 | 0.14 | 35 |
| | 1000 | 470 | 0.14 | 35 | 0.19 | 47 |
| | 1200 | 565 | 0.24 | 60 | 0.27 | 67 |
| | 1400 | 660 | 0.30 | 75 | 0.35 | 88 |
| CX34 - 31 | 600 | 285 | 0.07 | 17 | 0.08 | 20 |
| | 800 | 380 | 0.12 | 30 | 0.13 | 32 |
| | 1000 | 470 | 0.18 | 45 | 0.20 | 50 |
| | 1200 | 565 | 0.26 | 65 | 0.28 | 70 |
| | 1400 | 660 | 0.34 | 85 | 0.37 | 92 |
| CX34 - 36 | 800 | 380 | 0.13 | 32 | 0.14 | 35 |
| | 1000 | 470 | 0.19 | 47 | 0.21 | 52 |
| | 1200 | 565 | 0.27 | 67 | 0.30 | 75 |
| | 1400 | 660 | 0.34 | 85 | 0.39 | 97 |
| | 1600 | 760 | 0.45 | 112 | 0.51 | 127 |
| CX34 - 38 | 800 | 380 | 0.08 | 20 | 0.11 | 27 |
| | 1000 | 470 | 0.13 | 32 | 0.16 | 40 |
| | 1200 | 565 | 0.17 | 42 | 0.21 | 52 |
| | 1400 | 660 | 0.22 | 55 | 0.28 | 70 |
| | 1600 | 760 | 0.29 | 72 | 0.34 | 85 |

## Unit Specifications-coil pressure drop (continued)

| Model No | Air Volume | | Dry Coil | | Wet Coil | |
|---|---|---|---|---|---|---|
| | cfm | L/s | In. w.g. | pa | In. w.g. | pa |
| CX34 - 43 | 1000 | 470 | 0.07 | 17 | 0.09 | 22 |
| | 1200 | 565 | 0.10 | 25 | 0.12 | 30 |
| | 1400 | 660 | 0.13 | 32 | 0.16 | 40 |
| | 1600 | 760 | 0.16 | 40 | 0.20 | 50 |
| | 1800 | 850 | 0.20 | 50 | 0.24 | 60 |
| CX34 - 50/60 | 1200 | 565 | 0.13 | 32 | 0.17 | 42 |
| | 1400 | 660 | 0.18 | 45 | 0.23 | 57 |
| | 1600 | 760 | 0.23 | 57 | 0.29 | 72 |
| | 1800 | 850 | 0.28 | 70 | 0.37 | 92 |
| | 2000 | 945 | 0.34 | 85 | 0.43 | 107 |
| CX34 - 49 | 1200 | 565 | 0.08 | 20 | 0.12 | 30 |
| | 1400 | 660 | 0.13 | 32 | 0.17 | 42 |
| | 1600 | 760 | 0.17 | 42 | 0.22 | 55 |
| | 1800 | 850 | 0.22 | 55 | 0.28 | 70 |
| | 2000 | 945 | 0.28 | 70 | 0.35 | 87 |
| CX34 - 60 | 1400 | 660 | 0.11 | 27 | 0.15 | 37 |
| | 1600 | 760 | 0.14 | 35 | 0.18 | 45 |
| | 1800 | 850 | 0.17 | 42 | 0.21 | 52 |
| | 2000 | 945 | 0.21 | 52 | 0.27 | 67 |
| | 2200 | 1040 | 0.25 | 62 | 0.32 | 80 |
| | 2400 | 1135 | 0.30 | 75 | 0.37 | 92 |
| CX34 - 62 | 1400 | 660 | 0.15 | 37 | 0.19 | 47 |
| | 1600 | 760 | 0.19 | 47 | 0.23 | 57 |
| | 1800 | 850 | 0.24 | 60 | 0.28 | 70 |
| | 2000 | 945 | 0.29 | 72 | 0.34 | 85 |
| | 2200 | 1040 | 0.33 | 82 | 0.40 | 100 |
| | 2400 | 1135 | 0.39 | 97 | 0.46 | 115 |

# D L Manufacturing

## AIR HANDLER SPECIFICATIONS WITH OPTIONAL ELECTRIC HEAT, COOLING AND AIR SOURCE HEAT PUMPS




### Model Identification Number

**CB X 32 MV - 036 - 230 - 6 - 01**

Unit Type
CB = Air Handler

Refrigerant Type
X = R-410A

Series

Configuration
MV = Multi-Position, Variable Speed Blower Motor

Nominal Cooling Capacity-Tons
018/024 = 1.5 – 2.0 tons
024/030 = 2.0 – 2.5 tons
036 = 3.0 tons
048 = 4.0 tons
060 = 5.0 tons
068 = 5.0+tons

Voltage
230 = 208/230V-60hz-1ph

Refrigerant Metering Device
2 = Fixed Orifice
3 = TVX - bleedport (indoor unit)
4 = TVX - Non-bleedport (indoor unit)
5 = TVX - bleedport (outdoor unit)
6 = TVX - R-410A Non-bleedport (indoor unit)

Minor Revision #

**Electric Heat Data:**

| Model CBX32MV-018/024 and CBX32MV-024/030 | | | |
|---|---|---|---|
| Single Phase Electric Heat | | | |
| kW | kW range | Btuh range | Stages |
| 2.5 | 1.9 – 2.5 | 6,400 – 8,500 | 1 |
| 4.0 | 3.0 – 4.0 | 10,250 – 13,650 | 1 |
| 5.0 | 3.8 – 5.0 | 12,800 – 17,100 | 1 |
| 6.0 | 4.5 – 6.0 | 15,400 – 20,500 | 1 |
| 8.0 | 6.0 – 8.0 | 20,500 – 27,300 | 1 |
| 9.0 | 6.8 – 9.0 | 23,100 – 30,700 | 2 |
| 12.5 | 9.4 – 12.5 | 32,000 – 42,600 | 2 |
| 15.0 | 11.3 – 15.0 | 38,400 – 51,200 | 2 |

| Model CBX32MV-036 | | | |
|---|---|---|---|
| Single Phase Electric Heat | | | |
| kW | kW range | Btuh range | Stages |
| 4.0 | 3.0 – 4.0 | 10,250 – 13,650 | 1 |
| 5.0 | 3.8 – 5.0 | 12,800 – 17,100 | 1 |
| 6.0 | 4.5 – 6.0 | 15,400 – 20,500 | 1 |
| 8.0 | 6.0 – 8.0 | 20,500 – 27,300 | 1 |
| 9.0 | 6.8 – 9.0 | 23,100 – 30,700 | 2 |
| 12.5 | 9.4 – 12.5 | 32,000 – 42,600 | 2 |
| 15.0 | 11.3 – 15.0 | 38,400 – 51,200 | 2 |
| 20.0 | 15.0 – 20.0 | 51,200 – 68,200 | 2 |

| Model CBX32MV-048 and CBX32MV-060 | | | |
|---|---|---|---|
| Single Phase Electric Heat | | | |
| kW | kW range | Btuh range | Stages |
| 4.0 | 3.0 – 4.0 | 10,250 – 13,650 | 1 |
| 5.0 | 3.8 – 5.0 | 12,800 – 17,100 | 1 |
| 6.0 | 4.5 – 6.0 | 15,400 – 20,500 | 1 |
| 8.0 | 6.0 – 8.0 | 20,500 – 27,300 | 1 |
| 9.0 | 6.8 – 9.0 | 23,100 – 30,700 | 2 |
| 12.5 | 9.4 – 12.5 | 32,000 – 42,600 | 2 |
| 15.0 | 11.3 – 15.0 | 38,400 – 51,200 | 2 |
| 20.0 | 15.0 – 20.0 | 51,200 – 68,200 | 2 |
| 25.0 | 18.8 – 25.0 | 64,100 – 85,300 | 3 |

**Blower Performance:**

- 0.0 in. w.c. through 0.8 in. w.c. External Static Pressure Range
- The effect of electric heat, dry coil and standard filter pressure drop included
- Continuous blower speed is 50% of cooling speed setting

| Model CBX32MV-018/024 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Adjust Jumper Settings | Jumper Speed Settings | | | | | | | |
| | Heat Speed | | | | Cooling Speed | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | cfm | cfm | cfm | cfm | cfm | cfm | cfm | cfm |
| + | 715 | 855 | 1000 | 1130 | 465 | 690 | 900 | 1050 |
| Normal | 670 | 770 | 900 | 1035 | 425 | 620 | 825 | 950 |
| - | 580 | 700 | 800 | 930 | 385 | 560 | 735 | 850 |

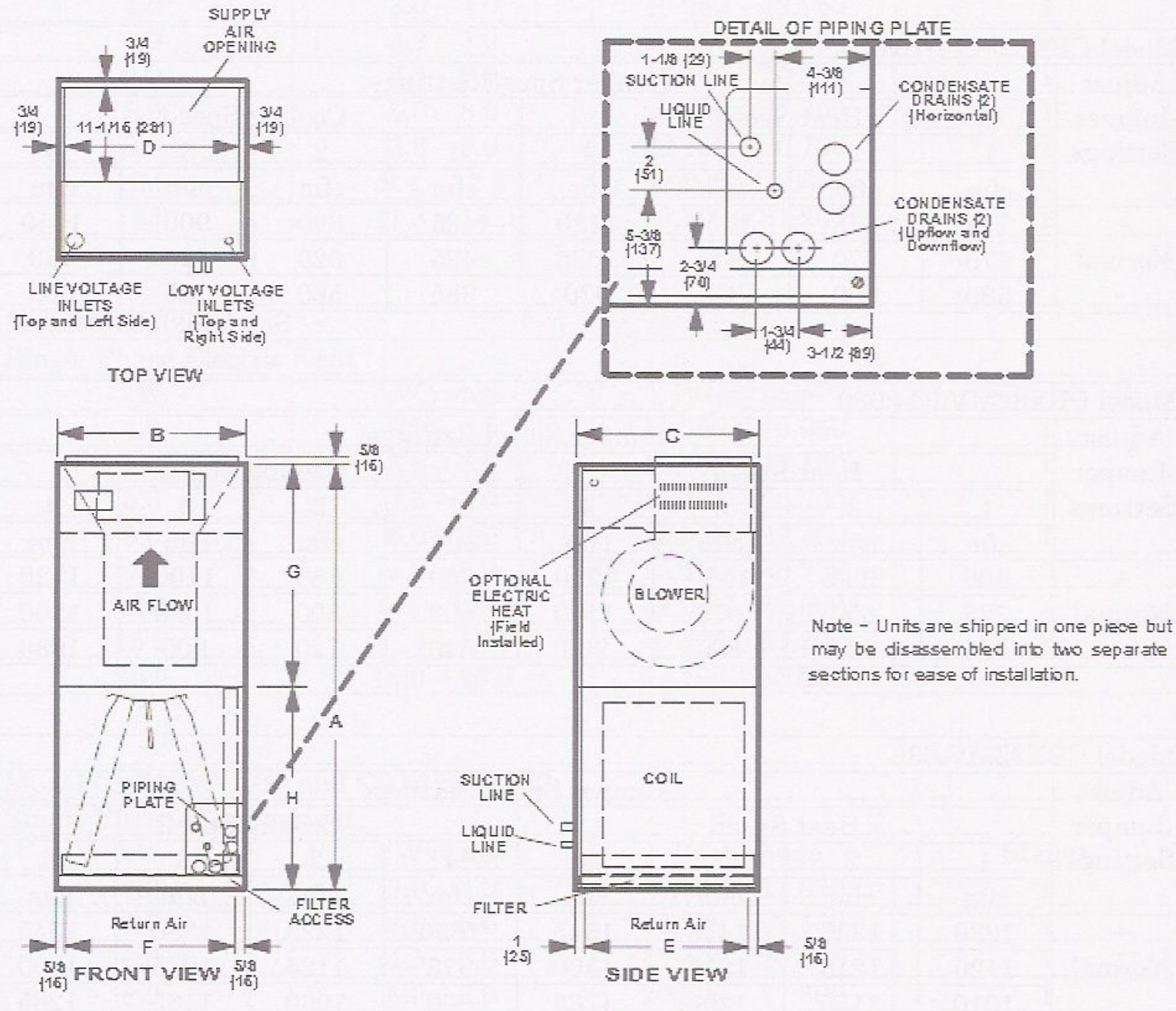
| Model CBX32MV-024/030 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Adjust Jumper Settings | Jumper Speed Settings | | | | | | | |
| | Heat Speed | | | | Cooling Speed | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | cfm | cfm | cfm | cfm | cfm | cfm | cfm | cfm |
| + | 800 | 935 | 1070 | 1210 | 660 | 880 | 1100 | 1320 |
| Normal | 725 | 850 | 975 | 1100 | 600 | 800 | 1000 | 1200 |
| - | 655 | 765 | 880 | 990 | 540 | 720 | 900 | 1080 |

| Model CBX32MV-036 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Adjust Jumper Settings | Jumper Speed Settings | | | | | | | |
| | Heat Speed | | | | Cooling Speed | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | cfm | cfm | cfm | cfm | cfm | cfm | cfm | cfm |
| + | 1230 | 1335 | 1445 | 1545 | 1090 | 1225 | 1380 | 1545 |
| Normal | 1120 | 1215 | 1315 | 1400 | 975 | 1125 | 1275 | 1400 |
| - | 1010 | 1185 | 1200 | 1265 | 900 | 1000 | 1135 | 1265 |

| Model CBX32MV-048 and CBX32MV-060 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Adjust Jumper Settings | Jumper Speed Settings | | | | | | | |
| | Heat Speed | | | | Cooling Speed | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | cfm | cfm | cfm | cfm | cfm | cfm | cfm | cfm |
| + | 1850 | 1960 | 2090 | 2150 | 1625 | 1820 | 2055 | 2145 |
| Normal | 1705 | 1800 | 1900 | 2005 | 1425 | 1625 | 1805 | 2005 |
| - | 1560 | 1625 | 1720 | 1770 | 1205 | 1375 | 1555 | 1725 |

## Unit Dimensions:

## Note: Support stand required for up-flow applications




| Model No. | CBX32MV-018/024 | | CBX32MV-024/030 | | CX32MV-036 | | CBX32MV-048 CBX32MV-060 | | CBX32MV-068 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | inch | mm | inch | mm | inch | mm | inch | mm | inch | mm |
| A | 45-1/4 | 1149 | 49-1/4 | 1251 | 51 | 1295 | 58-1/2 | 1486 | 64 | 1626 |
| B | 16-1/4 | 413 | 21-1/4 | 540 | 21-1/4 | 540 | 21-1/4 | 540 | 21-1/4 | 540 |
| C | 20-5/8 | 524 | 20-5/8 | 524 | 22-5/8 | 878 | 24-7/8 | 625 | 26-5/8 | 675 |
| D | 14-3/4 | 375 | 19-3/4 | 502 | 19-3/4 | 502 | 19-3/4 | 502 | 19-3/4 | 502 |
| E | 19 | 483 | 19 | 483 | 21 | 533 | 23 | 584 | 25 | 635 |
| F | 15 | 381 | 20 | 508 | 20 | 508 | 20 | 508 | 20 | 508 |
| G | 24-5/8 | 625 | 24-5/8 | 625 | 26-3/4 | 640 | 27-7/8 | 708 | 31-3/8 | 797 |
| H | 20-5/8 | 524 | 24-5/8 | 625 | 24-5/8 | 625 | 30-5/8 | 778 | 32-5/8 | 829 |

# D L MANUFACTURING

## HEAT PUMP OUTDOOR UNIT SPECIFICATIONS


**Nominal Cooling Capacity – 1.5 to 5 Tons**

**Heating Capacity 16,800 to 55,000 Btuh**

### Model Identification Number

**14 HP X - 036 - 230 - 01**

- 14 – Nominal SEER
- HP – Unit Type: HP = Heat Pump Outdoor Unit
- X – Refrigerant: X = R-410A
- 036 – Nominal Cooling Capacity:
  - 018 = 1.5 tons
  - 024 = 2.0 tons
  - 030 = 2.5 tons
  - 036 = 3.0 tons
  - 048 = 4.0 tons
  - 060 = 5.0 tons
- 230 – Voltage: 230 = 208/230V - 1 phase - 60hz
- 01 – Minor Revision #

## Outdoor Unit Performance Data:

| Model No. (Outdoor Unit) | Cooling Capacity | SEER | EER | Heat Capacity | | HSPF | Coil or Air Handler |
|---|---|---|---|---|---|---|---|
| | | | | High | Low | | |
| 14HPX-018-230 | 19,100 | 14.00 | 12.00 | 16,800 | 10,100 | 7.75 | CBX32MV-018/024 |
| 14HPX-024-230 | 23,600 | 14.00 | 12.00 | 23,200 | 14,700 | 8.20 | CBX32MV-024/030 |
| 14HPX-024-230 | 23,400 | 14.00 | 11.50 | 23,200 | 14,800 | 7.20 | CBX32MV-018/024 |
| 14HPX-030-230 | 28,000 | 14.00 | 12.00 | 28,200 | 17,000 | 8.20 | CBX32MV-024/030 |
| 14HPX-030-230 | 28,400 | 14.50 | 12.00 | 28,000 | 16,800 | 7.00 | CBX32MV-036 |
| 14HPX-036-230 | 34,600 | 14.00 | 12.0 | 35,400 | 21,200 | 8.50 | CBX32MV-036 |
| 14HPX-036-230 | 35,800 | 15.00 | 12.50 | 35,200 | 21,200 | 7.20 | CBX32MV-048 |
| 14HPX-048-230 | 48,000 | 14.00 | 11.50 | 47,000 | 30,000 | 8.50 | CBX32MV-048 |
| 14HPX-048-230 | 48,500 | 14.00 | 12.00 | 46,500 | 30,000 | 7.20 | CBX32MV-060 |
| 14HPX-060-230 | 56,000 | 14.00 | 11.50 | 55,000 | 35,600 | 8.20 | CBX32MV-060 |
| 14HPX-060-230 | 56,500 | 14.00 | 11.50 | 55,000 | 35,800 | 8.20 | CBX32MV-060 |
| 14HPX-060-230 | 56,500 | 14.00 | 11.50 | 54,500 | 35,400 | 8.20 | CBX32MV-068 |

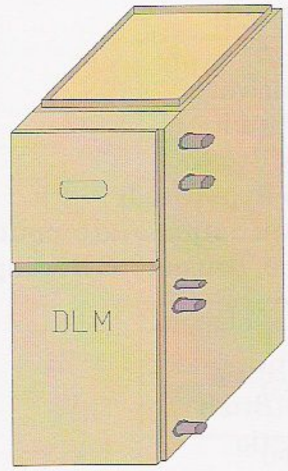
High temperature heat ratings: 47°F outdoor air temperature and 70°F indoor air temperature entering indoor coil.

Low temperature heat ratings: 17°F outdoor air temperature and 70°F indoor air temperature entering indoor coil.

Cooling ratings: 95°F outdoor air ambient and 80°F db/67°F wb entering air temperature at indoor coil.

# D L MANUFACTURING

## Geothermal Heat Pump Specifications (Simplified)




### Model Identification Number

N V V 048 A 1 0 1 C T L 0 J N

Unit Type
N - series

Compressor Type
V = variable Speed

Cabinet Type
V = Vertical
H = Horizontal

Unit Capacity
036, 048, 060

Vintage
A = Current

Voltage
1 = 208-230/60/1

Hot Water Generation
0 = No Hot water Generation
1 = Hot Water Generation

Blower Option
1 = ECM, 2 = High Static ECM

Water Coil Option
C = Copper, N = Cupronickel

Discharge Air Configuration
T = Top, B = Bottom, R = Rear
S = Side, E = End

Return Air Configuration
L = Left, R = Right

Filter Option
0 = 2 in. MERV 11 Filter
1 = Alpine Pure 411

Control Option
J = Variable Speed Control
K = variable Speed Control
With Performance Monitoring

Future Option
N = None

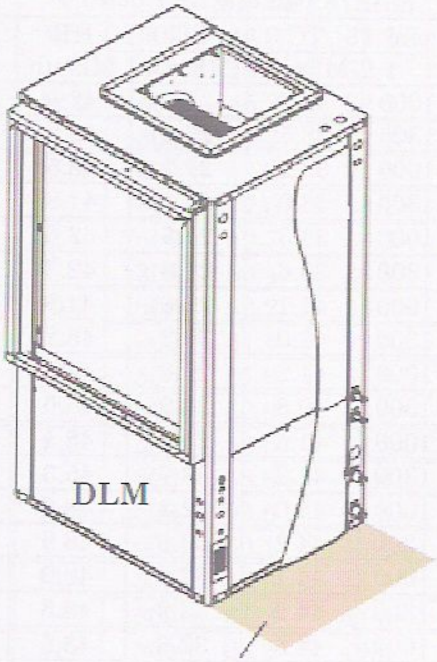
## Abbreviations and Definitions

cfm = airflow cubic feet/minute
EWT = entering water temperature
gpm = water flow in gallons/minute
WPD = water pressure drop, psi and feet of water
EAT = entering air temperature, Fahrenheit (dry bulb/wet bulb)
HC = air heating capacity, MBtu/h
TC = total cooling capacity, MBtu/h
SC = sensible cooling capacity
kW = total power unit input, kilowatts
HR = total heat of rejection, MBtu/h
HE = total heat of extraction, MBtu/h
HWC = hot water generator capacity, MBtu/h
EER = Energy Efficient Ratio, Btu output/Watt input
COP = Coefficient of Performance, Btu output/Btu input
LWT = leaving water temperature, °F
LAT = leaving air temperature, °F
TH = total heating capacity, MBtu/h
LC = latent cooling capacity, MBtu/h
S/T = sensible to total cooling ratio

## Reference Calculations

| Heating calculations: | Cooling calculations: |
|---|---|
| $LWT = EWT - \left[\dfrac{HE}{gpm \times 500}\right]$ | $LWT = EWT + \left[\dfrac{HE}{gpm \times 500}\right]$ |
| $LAT = EAT + \left[\dfrac{HC}{cfm \times 1.08}\right]$ | $LAT\ (db) = EAT\ (db) - \left[\dfrac{SC}{cfm \times 1.08}\right]$ |
| $TH = HC + HW$ | $LC = TC - SC$ |
| | $S/T = \dfrac{SC}{TC}$ |

**Cabinet Data:**




| Model Number | Supply Air Opening Size |
|---|---|
| 036 | 18" x 18" |
| 048 | 18" x 18" |
| 060 | 18" x 18" |

| Model Number | Return Air Filter Size |
|---|---|
| 036 | 28" x 30" |
| 048 | 28" x 30" |
| 060 | 28" x 34" |

## Unit Specifications (Performance Ratings) - Full Load

### Model 036

| EWT °F | Flow gpm | Heating – EAT 70°F | | | | | EWT °F | Flow gpm | Cooling – EAT 80/67°F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | cfm | HC MBtuh | HE MBtuh | LAT °F | COP | | | cfm | TC MBtuh | SC MBtuh | HR MBtuh | EER |
| 30 | 5.5 | 1150 | 35.3 | 25.9 | 98.4 | 3.77 | 30 | 4.5 | 1000 | 39.2 | 27.3 | 42.6 | 40.1 |
| | | 1500 | 36.0 | 26.4 | 92.2 | 3.78 | | | 1300 | 38.5 | 27.4 | 42.2 | 35.2 |
| | 8.0 | 1150 | 35.6 | 26.1 | 98.6 | 3.77 | | 7.0 | 1000 | 39.2 | 27.3 | 42.5 | 41.5 |
| | | 1500 | 36.3 | 26.7 | 92.4 | 3.77 | | | 1300 | 38.0 | 28.1 | 41.9 | 33.2 |
| | 11.5 | 1150 | 36.1 | 26.1 | 99.1 | 3.62 | | 9.0 | 1000 | 39.3 | 27.5 | 42.6 | 41.5 |
| | | 1500 | 37.4 | 27.5 | 93.1 | 3.79 | | | 1300 | 38.6 | 27.8 | 42.3 | 36.1 |
| 40 | 5.5 | 1150 | 40.9 | 31.6 | 103.0 | 4.40 | 40 | 4.5 | 1000 | 41.1 | 29.6 | 44.9 | 37.4 |
| | | 1500 | 41.5 | 32.1 | 95.6 | 4.39 | | | 1300 | 41.0 | 30.3 | 45.2 | 33.3 |
| | 8.0 | 1150 | 41.3 | 32.0 | 103.3 | 4.42 | | 7.0 | 1000 | 41.2 | 29.6 | 44.8 | 38.8 |
| | | 1500 | 42.3 | 32.8 | 96.1 | 4.43 | | | 1300 | 40.8 | 30.9 | 45.0 | 32.8 |
| | 11.5 | 1150 | 42.5 | 32.9 | 104.2 | 4.44 | | 9.0 | 1000 | 41.5 | 29.8 | 45.1 | 39.1 |
| | | 1500 | 43.3 | 33.6 | 96.7 | 4.46 | | | 1300 | 41.3 | 30.7 | 45.3 | 35.1 |
| 50 | 5.5 | 1150 | 46.0 | 36.2 | 107.0 | 4.73 | 50 | 4.5 | 1000 | 44.0 | 32.3 | 48.3 | 35.1 |
| | | 1500 | 46.4 | 36.6 | 98.7 | 4.72 | | | 1300 | 44.2 | 33.6 | 48.9 | 31.5 |
| | 8.0 | 1150 | 46.4 | 36.7 | 107.4 | 4.79 | | 7.0 | 1000 | 44.1 | 32.4 | 48.2 | 36.5 |
| | | 1500 | 47.6 | 37.7 | 99.4 | 4.80 | | | 1300 | 44.2 | 33.9 | 48.8 | 32.1 |
| | 11.5 | 1150 | 47.5 | 37.5 | 108.2 | 4.74 | | 9.0 | 1000 | 44.5 | 32.6 | 48.6 | 37.3 |
| | | 1500 | 48.5 | 38.5 | 99.9 | 4.83 | | | 1300 | 44.6 | 33.9 | 49.1 | 34.0 |
| 60 | 5.5 | 1150 | 50.8 | 41.0 | 110.9 | 5.18 | 60 | 4.5 | 1000 | 40.3 | 30.9 | 45.3 | 27.8 |
| | | 1500 | 51.6 | 41.7 | 101.9 | 5.23 | | | 1300 | 41.3 | 32.8 | 46.7 | 25.9 |
| | 8.0 | 1150 | 52.0 | 42.2 | 111.9 | 5.29 | | 7.0 | 1000 | 40.5 | 31.0 | 45.2 | 28.9 |
| | | 1500 | 52.8 | 42.8 | 102.6 | 5.29 | | | 1300 | 41.5 | 33.0 | 46.7 | 26.8 |
| | 11.5 | 1150 | 53.2 | 43.2 | 112.8 | 5.31 | | 9.0 | 1000 | 40.9 | 31.2 | 45.6 | 29.5 |
| | | 1500 | 54.3 | 44.1 | 103.5 | 5.36 | | | 1300 | 41.7 | 33.1 | 46.7 | 28.0 |
| 70 | 5.5 | 1150 | 54.9 | 44.8 | 114.2 | 5.45 | 70 | 4.5 | 1000 | 38.9 | 30.3 | 44.6 | 23.2 |
| | | 1500 | 56.4 | 46.2 | 104.8 | 5.51 | | | 1300 | 36.8 | 29.7 | 43.1 | 20.0 |
| | 8.0 | 1150 | 56.9 | 46.6 | 115.8 | 5.52 | | 7.0 | 1000 | 39.1 | 30.5 | 44.6 | 24.2 |
| | | 1500 | 57.9 | 47.8 | 105.7 | 5.75 | | | 1300 | 41.0 | 33.0 | 47.0 | 23.6 |
| | 11.5 | 1150 | 58.7 | 48.2 | 117.3 | 5.58 | | 9.0 | 1000 | 36.2 | 26.0 | 41.7 | 22.3 |
| | | 1500 | 60.0 | 49.7 | 107.0 | 5.84 | | | 1300 | 41.0 | 33.3 | 46.8 | 24.3 |
| 80 | 5.5 | 1150 | 60.2 | 49.4 | 118.4 | 5.59 | 80 | 4.5 | 1000 | 37.8 | 30.7 | 44.5 | 19.4 |
| | | 1500 | 61.3 | 50.5 | 107.8 | 5.68 | | | 1300 | 38.8 | 32.8 | 45.9 | 18.7 |
| | 8.0 | 1150 | 63.0 | 52.1 | 120.7 | 5.80 | | 7.0 | 1000 | 38.1 | 30.9 | 44.5 | 20.3 |
| | | 1500 | 63.4 | 52.6 | 109.1 | 5.85 | | | 1300 | 39.2 | 32.8 | 46.0 | 19.8 |
| | 11.5 | 1150 | 63.9 | 52.8 | 121.4 | 5.79 | | 9.0 | 1000 | 38.5 | 31.2 | 44.8 | 20.8 |
| | | 1500 | 65.1 | 54.0 | 110.2 | 5.87 | | | 1300 | 39.4 | 33.2 | 46.0 | 20.5 |

## Model 048

| EWT °F | Flow gpm | Heating – EAT 70°F | | | | | EWT °F | Flow gpm | Cooling – EAT 80/67°F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | cfm | HC MBtuh | HE MBtuh | LAT °F | COP | | | cfm | TC MBtuh | SC MBtuh | HR MBtuh | EER |
| 30 | 6.5 | 1500 | 44.9 | 31.7 | 97.7 | 3.41 | 30 | 5.5 | 1000 | 52.6 | 36.3 | 56.7 | 43.4 |
| | | 1800 | 45.8 | 32.4 | 93.5 | 3.41 | | | 1400 | 51.5 | 36.3 | 56.1 | 38.2 |
| | 10.0 | 1500 | 45.3 | 32.0 | 98.0 | 3.40 | | 8.0 | 1000 | 52.5 | 36.2 | 56.5 | 45.0 |
| | | 1800 | 46.2 | 32.6 | 93.8 | 3.41 | | | 1400 | 50.9 | 37.3 | 55.7 | 36.0 |
| | 13.5 | 1500 | 45.9 | 31.9 | 98.4 | 3.27 | | 10.5 | 1000 | 52.7 | 36.5 | 56.7 | 45.0 |
| | | 1800 | 47.6 | 33.7 | 94.5 | 3.43 | | | 1400 | 51.7 | 36.9 | 56.2 | 39.2 |
| 40 | 6.5 | 1500 | 49.7 | 36.3 | 100.7 | 3.70 | 40 | 5.5 | 1000 | 53.8 | 37.2 | 58.6 | 38.5 |
| | | 1800 | 50.4 | 36.8 | 95.9 | 3.70 | | | 1400 | 53.7 | 38.1 | 59.0 | 34.3 |
| | 10.0 | 1500 | 50.2 | 36.7 | 101.0 | 3.72 | | 8.0 | 1000 | 53.9 | 37.2 | 58.5 | 39.9 |
| | | 1800 | 51.4 | 37.6 | 96.4 | 3.73 | | | 1400 | 53.4 | 38.8 | 58.8 | 33.8 |
| | 13.5 | 1500 | 51.6 | 37.8 | 101.8 | 3.74 | | 10.5 | 1000 | 54.3 | 37.4 | 58.9 | 40.3 |
| | | 1800 | 52.6 | 38.6 | 97.1 | 3.75 | | | 1400 | 54.0 | 38.6 | 59.1 | 36.2 |
| 50 | 6.5 | 1500 | 58.0 | 44.2 | 105.8 | 4.20 | 50 | 5.5 | 1000 | 56.7 | 38.9 | 62.3 | 34.7 |
| | | 1800 | 58.6 | 44.6 | 100.1 | 4.20 | | | 1400 | 56.9 | 40.4 | 63.2 | 31.1 |
| | 10.0 | 1500 | 58.6 | 44.8 | 106.2 | 4.26 | | 8.0 | 1000 | 56.9 | 39.0 | 62.2 | 36.0 |
| | | 1800 | 60.1 | 46.0 | 100.9 | 4.27 | | | 1400 | 56.9 | 40.8 | 63.1 | 31.7 |
| | 13.5 | 1500 | 59.9 | 45.7 | 107.0 | 4.22 | | 10.5 | 1000 | 57.4 | 39.2 | 62.8 | 36.6 |
| | | 1800 | 61.2 | 47.0 | 101.5 | 4.30 | | | 1400 | 57.5 | 40.8 | 63.3 | 33.6 |
| 60 | 6.5 | 1500 | 63.2 | 49.6 | 109.0 | 4.64 | 60 | 5.5 | 1000 | 51.2 | 36.5 | 57.7 | 27.2 |
| | | 1800 | 64.2 | 50.5 | 103.0 | 4.67 | | | 1400 | 52.4 | 38.8 | 59.4 | 25.4 |
| | 10.0 | 1500 | 64.7 | 51.0 | 110.0 | 4.73 | | 8.0 | 1000 | 51.4 | 36.7 | 57.6 | 28.4 |
| | | 1800 | 65.7 | 51.8 | 103.8 | 4.73 | | | 1400 | 52.7 | 39.0 | 59.5 | 26.3 |
| | 13.5 | 1500 | 66.2 | 52.2 | 110.8 | 4.75 | | 10.5 | 1000 | 51.9 | 36.9 | 58.0 | 28.9 |
| | | 1800 | 67.5 | 53.4 | 104.7 | 4.79 | | | 1400 | 52.9 | 39.2 | 59.5 | 27.5 |
| 70 | 6.5 | 1500 | 67.6 | 53.9 | 111.7 | 4.93 | 70 | 5.5 | 1000 | 48.8 | 35.0 | 56.4 | 22.0 |
| | | 1800 | 68.3 | 54.9 | 105.1 | 5.08 | | | 1400 | 47.6 | 34.4 | 56.2 | 18.9 |
| | 10.0 | 1500 | 71.3 | 57.7 | 114.0 | 5.23 | | 8.0 | 1000 | 49.0 | 35.2 | 56.3 | 23.0 |
| | | 1800 | 71.6 | 57.9 | 106.9 | 5.23 | | | 1400 | 51.5 | 38.0 | 59.3 | 22.4 |
| | 13.5 | 1500 | 72.6 | 56.9 | 114.8 | 4.62 | | 10.5 | 1000 | 44.0 | 29.9 | 51.4 | 20.3 |
| | | 1800 | 74.3 | 60.3 | 108.2 | 5.31 | | | 1400 | 51.5 | 38.4 | 59.1 | 23.1 |
| 80 | 6.5 | 1500 | 74.9 | 61.3 | 116.3 | 5.48 | 80 | 5.5 | 1000 | 47.5 | 35.2 | 56.2 | 18.5 |
| | | 1800 | 76.3 | 62.6 | 109.3 | 5.57 | | | 1400 | 48.7 | 37.6 | 58.1 | 17.8 |
| | 10.0 | 1500 | 78.3 | 64.4 | 118.3 | 5.63 | | 8.0 | 1000 | 47.8 | 35.5 | 56.2 | 19.4 |
| | | 1800 | 79.0 | 65.2 | 110.6 | 5.74 | | | 1400 | 49.2 | 37.6 | 58.1 | 18.9 |
| | 13.5 | 1500 | 79.6 | 65.5 | 119.1 | 5.65 | | 10.5 | 1000 | 48.3 | 35.8 | 56.5 | 19.9 |
| | | 1800 | 81.1 | 67.0 | 111.7 | 5.72 | | | 1400 | 49.5 | 38.0 | 58.1 | 19.6 |

## Model 060

| EWT °F | Flow gpm | Heating – EAT 70°F | | | | | EWT °F | Flow gpm | Cooling – EAT 80/67°F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | cfm | HC MBtuh | HE MBtuh | LAT °F | COP | | | cfm | TC MBtuh | SC MBtuh | HR MBtuh | EER |
| 30 | 8.5 | 1800 | 56.8 | 39.5 | 99.2 | 3.28 | 30 | 6.5 | 1000 | 69.5 | 46.4 | 75.9 | 37.4 |
| | | 2200 | 57.9 | 40.3 | 94.4 | 3.29 | | | 1400 | 68.1 | 46.4 | 75.2 | 32.8 |
| | 13.0 | 1800 | 57.3 | 39.8 | 99.5 | 3.28 | | 10.0 | 1000 | 69.5 | 46.3 | 75.7 | 38.6 |
| | | 2200 | 58.4 | 40.6 | 94.6 | 3.28 | | | 1400 | 67.3 | 47.7 | 74.7 | 30.9 |
| | 17.0 | 1800 | 58.1 | 39.7 | 99.9 | 3.15 | | 13.5 | 1000 | 69.7 | 46.7 | 75.9 | 38.6 |
| | | 2200 | 60.2 | 42.0 | 95.3 | 3.30 | | | 1400 | 68.4 | 47.2 | 75.3 | 33.6 |
| 40 | 8.5 | 1800 | 64.8 | 47.2 | 103.3 | 3.68 | 40 | 6.5 | 1000 | 68.6 | 46.5 | 75.9 | 37.4 |
| | | 2200 | 65.7 | 47.8 | 97.7 | 3.68 | | | 1400 | 68.4 | 47.6 | 75.2 | 32.8 |
| | 13.0 | 1800 | 65.4 | 47.7 | 103.7 | 3.70 | | 10.0 | 1000 | 68.6 | 46.5 | 75.7 | 38.6 |
| | | 2200 | 66.9 | 48.9 | 98.2 | 3.71 | | | 1400 | 68.0 | 48.5 | 74.7 | 30.9 |
| | 17.0 | 1800 | 67.2 | 49.1 | 104.6 | 3.72 | | 13.5 | 1000 | 69.2 | 46.8 | 75.9 | 38.6 |
| | | 2200 | 68.5 | 50.2 | 98.8 | 3.73 | | | 1400 | 68.8 | 48.3 | 75.3 | 33.6 |
| 50 | 8.5 | 1800 | 72.2 | 54.2 | 107.1 | 4.01 | 50 | 6.5 | 1000 | 68.6 | 47.0 | 76.6 | 29.1 |
| | | 2200 | 72.9 | 54.7 | 100.7 | 4.00 | | | 1400 | 68.8 | 48.8 | 77.8 | 26.1 |
| | 13.0 | 1800 | 73.0 | 55.0 | 107.5 | 4.06 | | 10.0 | 1000 | 68.7 | 47.1 | 76.5 | 30.2 |
| | | 2200 | 74.9 | 56.4 | 101.5 | 4.07 | | | 1400 | 68.8 | 49.3 | 77.6 | 26.6 |
| | 17.0 | 1800 | 74.6 | 56.0 | 108.4 | 4.02 | | 13.5 | 1000 | 69.4 | 47.4 | 77.1 | 30.7 |
| | | 2200 | 76.2 | 57.6 | 102.1 | 4.10 | | | 1400 | 69.5 | 49.3 | 77.9 | 28.2 |
| 60 | 8.5 | 1800 | 80.8 | 62.3 | 111.6 | 4.37 | 60 | 6.5 | 1000 | 63.8 | 45.2 | 72.9 | 23.8 |
| | | 2200 | 82.1 | 63.5 | 104.6 | 4.40 | | | 1400 | 65.2 | 48.0 | 75.2 | 22.3 |
| | 13.0 | 1800 | 82.8 | 64.2 | 112.6 | 4.45 | | 10.0 | 1000 | 64.0 | 45.4 | 72.8 | 24.8 |
| | | 2200 | 84.0 | 65.1 | 105.3 | 4.45 | | | 1400 | 65.5 | 48.2 | 75.3 | 23.0 |
| | 17.0 | 1800 | 84.6 | 65.7 | 113.5 | 4.47 | | 13.5 | 1000 | 64.6 | 45.7 | 73.3 | 25.3 |
| | | 2200 | 86.4 | 67.2 | 106.3 | 4.51 | | | 1400 | 65.9 | 48.4 | 75.2 | 24.1 |
| 70 | 8.5 | 1800 | 88.4 | 69.0 | 115.5 | 4.56 | 70 | 6.5 | 1000 | 60.2 | 44.1 | 70.5 | 19.9 |
| | | 2200 | 89.9 | 70.7 | 107.8 | 4.68 | | | 1400 | 62.7 | 47.2 | 74.4 | 18.4 |
| | 13.0 | 1800 | 93.2 | 73.9 | 117.9 | 4.83 | | 10.0 | 1000 | 60.5 | 44.4 | 70.4 | 20.8 |
| | | 2200 | 93.6 | 74.2 | 109.4 | 4.83 | | | 1400 | 63.5 | 47.9 | 74.2 | 20.3 |
| | 17.0 | 1800 | 95.0 | 74.8 | 118.8 | 4.71 | | 13.5 | 1000 | 62.2 | 44.0 | 71.9 | 21.7 |
| | | 2200 | 97.1 | 77.3 | 110.9 | 4.91 | | | 1400 | 63.5 | 48.4 | 73.9 | 20.9 |
| 80 | 8.5 | 1800 | 97.6 | 78.0 | 120.2 | 4.98 | 80 | 6.5 | 1000 | 58.1 | 43.6 | 70.0 | 16.7 |
| | | 2200 | 99.4 | 79.8 | 111.8 | 5.06 | | | 1400 | 59.6 | 46.6 | 72.3 | 16.1 |
| | 13.0 | 1800 | 102.0 | 82.1 | 122.5 | 5.12 | | 10.0 | 1000 | 58.5 | 43.9 | 69.9 | 17.5 |
| | | 2200 | 102.9 | 83.2 | 113.3 | 5.21 | | | 1400 | 60.2 | 46.6 | 72.3 | 17.1 |
| | 17.0 | 1800 | 103.7 | 83.1 | 123.3 | 5.04 | | 13.5 | 1000 | 59.1 | 44.3 | 70.3 | 18.0 |
| | | 2200 | 105.7 | 85.4 | 114.5 | 5.19 | | | 1400 | 60.5 | 47.1 | 72.2 | 17.6 |

## Blower Performance Data:

| Model | Max ESP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Airflow Speed | | | | | | | | | | | |
| 036 | 0.50 | **285** | **380** G | **525** L | **675** | **815** | **980** | 1100 | 1220 | 1330 | 1440 H | 1540 Aux | 1575 |
| 036* 1 hp | 0.75 | **480** | **565** G | **665** L | **761** | **870** | **1000** | 1100 | 1200 | 1300 | 1410 H | 1520 Aux | 1630 |
| 048 | 0.75 | **475** | **620** G | **730** L | **850** | **1020** | **1140** | 1270 | 1400 | 1520 | 1650 H | 1790 Aux | 1925 |
| 060 | 0.75 | **400** | **600** G | **830** L | **1050** | **1230** | **1400** | 1560 | 1700 | 1870 | 2010 H | 2140 Aux | 2265 |
| **VS Compressor Speed | | | | 1-2 | 3-4 | | 5-6 | 7-8 | | 9-10 | 11-12 | | |

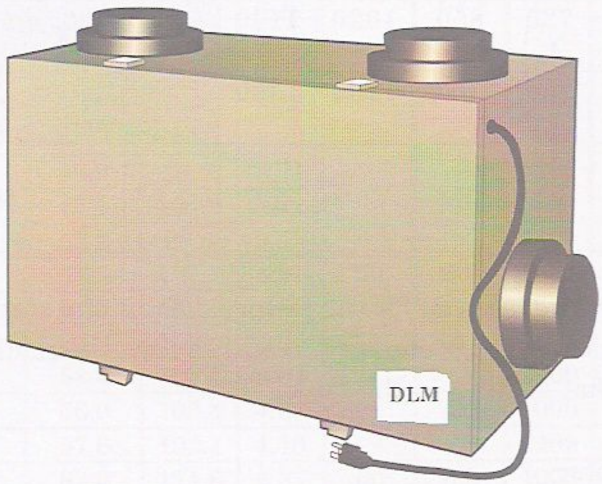
- ** VS Compressor speed is given for the factory default cfm settings. When the factory cfm default settings are changed, it will change the relationship to the compressor speed that is given in the table.
- ECM Motor.
- * Optional 1 HP motor.
- Factory settings are at recommended L, H, and Aux positions.
- "G" may be located anywhere within table.
- "L" should be located within the **boldface** cfm range.
- "H" must be located within the shaded cfm range.
- "Aux" setting must be equal to or greater than "H" setting.
- "Aux" setting must be at least the minimum setting for the Auxiliary Heater selected.
- Cfm is controlled within 5% up to the maximum ESP.
- Maximum ESP includes allowance for wet coil and standard filter.
- Note: Blower speed settings may be field adjusted, + or – adjustments for cooling.

## Auxiliary Heat Data:

| Model | kW 208V | kW 230V | Stages | Btu/h 208V | Btu/h 230V | Min Cfm | Model Compatibility 036 | 048 | 060 |
|---|---|---|---|---|---|---|---|---|---|
| 10 kW | 7.2 | 9.6 | 2 | 24,600 | 32,700 | 1100 | * | * | * |
| 15 kW | 10.8 | 14.4 | 3 | 36,900 | 49,100 | 1250 | * | * | * |
| 20 kW | 14.4 | 19.2 | 4 | 49,200 | 65,500 | 1500 | | * | * |

# D L MANUFACTURING

## HRV/ERV SPECIFICATIONS




### Model Identification Number

**HRV 3 - 200**

Unit Type
HRV = Heat Recovery Ventilator
ERV = Energy Recovery Ventilator

Generation

Air Capacity in CFM
095 = 95 cfm (single core)
150 = 150 cfm (single core)
200 = 200 cfm (single core)
195 = 195 cfm (dual core)
300 = 300 cfm (dual core)

## Unit Specifications

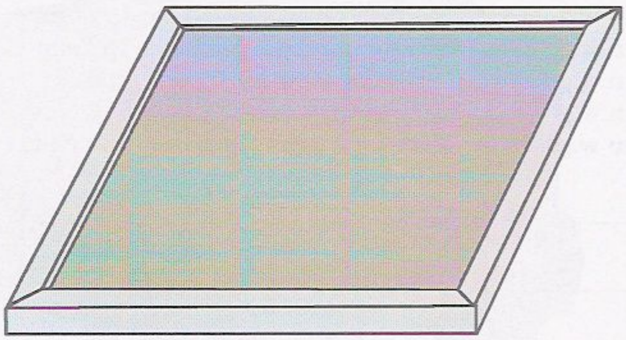
| Model No<br>No of cores | HRV3-095<br>single | HRV3-150<br>single | HRV3-200<br>single | HRV3-195<br>dual | HRV3-300<br>dual |
|---|---|---|---|---|---|
| Sensible effectiveness @ 32°F<br>Sensible efficiency @ 32°F<br>Sensible efficiency @ -13°F | 88%-60 cfm<br>75%-60 cfm<br>68%-61 cfm | 76%-65 cfm<br>64%-65 cfm<br>66%-68 cfm | 74%-66 cfm<br>64%-66 cfm<br>62%-109 cfm | 88%-114 cfm<br>81%-114 cfm<br>77%-119 cfm | 90%-119 cfm<br>79%-119 cfm<br>75%-125 cfm |
| Airflow @ Static Pressure | | | | | |
| 0.1 in w.g. | 76 cfm | 150 cfm | 207 cfm | 203 cfm | 265 cfm |
| 0.2 in w.g. | 73 cfm | 146 cfm | 200 cfm | 191 cfm | 260 cfm |
| 0.3 in w.g. | 70 cfm | 134 cfm | 184 cfm | 182 cfm | 250 cfm |
| 0.4 in w.g. | 66 cfm | 121 cfm | 171 cfm | 167 cfm | 235 cfm |
| 0.5 in w.g. | 60 cfm | 106 cfm | 152 cfm | 155 cfm | 220 cfm |
| 0.6 in w.g. | ---- | 92 cfm | 130 cfm | 138 cfm | 203 cfm |
| 0.7 in w.g. | ---- | ---- | 116 cfm | 104 cfm | 186 cfm |
| 0.8 in w.g. | ---- | ---- | 86 cfm | ---- | 167 cfm |
| Number of Speeds | 2 | 2 | 2 | 2 | 2 |
| Number of Speeds with optional control | 5 | 5 | 5 | 5 | 5 |
| Defrost Type | Recirculating | Recirculating | Recirculating | Damper | Damper |

| Model No<br>No of cores | ERV3-150<br>single | ERV3-200<br>single |
|---|---|---|
| Sensible effectiveness @ 32°F<br>Sensible efficiency @ 32°F<br>Latent efficiency 95°F<br>Total efficiency 95°F | 81%-64 cfm<br>69%-64 cfm<br>37%-64 cfm<br>47%-64 cfm | 76%-117 cfm<br>69%-117 cfm<br>41%-117 cfm<br>59%-117 cfm |
| Airflow @ Static Pressure | | |
| 0.1 in w.g. | 151 cfm | 180 cfm |
| 0.2 in w.g. | 140 cfm | 169 cfm |
| 0.3 in w.g. | 131 cfm | 157 cfm |
| 0.4 in w.g. | 123 cfm | 146 cfm |
| 0.5 in w.g. | 107 cfm | 132 cfm |
| 0.6 in w.g. | 98 cfm | 118 cfm |
| 0.7 in w.g. | 81 cfm | 101 cfm |
| 0.8 in w.g. | 60 cfm | 82 cfm |
| Number of Speeds | 1 | 1 |
| Number of Speeds with optional control | 5 | 5 |

# D L MANUFACTURING

## FIBERGLASS FILTER SPECIFICATIONS

### 1" FIBERGLASS FILTERS



## Features:

- Hard dust holding capacity
- Standard and specialized sizes to fit all residential air handling equipment
- Available in packages of three or cartons of ten

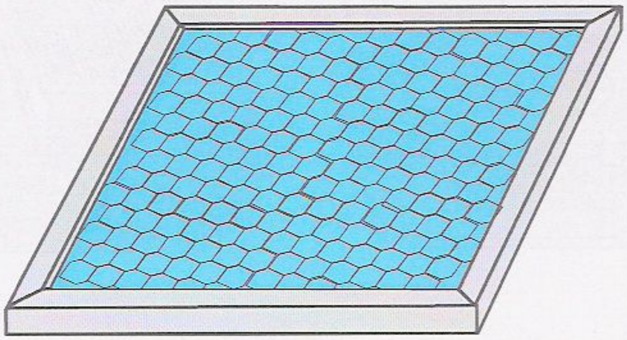
## Performance Data:

| Nominal Size | Initial pressure drop @ face velocity | | | CFM Capacity @ face velocity | | |
|---|---|---|---|---|---|---|
| | 300 fpm | 400 fpm | 500 fpm | 300 fpm | 400 fpm | 500 fpm |
| 10 X 20 X 1" | .05 | .08 | .14 | 300 | 400 | 500 |
| 16 X 20 X 1" | .05 | .08 | .14 | 525 | 700 | 875 |
| 16 X 25 X 1" | .05 | .08 | .14 | 671 | 894 | 1118 |
| 20 X 20 X 1" | .05 | .08 | .14 | 675 | 900 | 1125 |
| 20 X 25 X 1" | .05 | .08 | .14 | 863 | 1150 | 1438 |
| 28 X 30 X 1" | .05 | .08 | .14 | 1260 | 1680 | 2100 |
| 28 X 34 X 1" | .05 | .08 | .14 | 1428 | 1904 | 2380 |

# D L MANUFACTURING

## ALUMINUM FILTER SPECIFICATIONS

## 1" FIBERGLASS FILTERS



## Features:

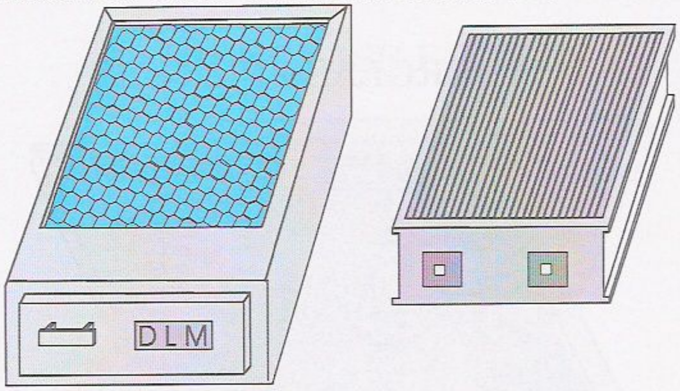
- Strong for long service life
- Easy to clean, never needs replacing
- Standard and specialized sizes to fit all residential air handling equipment
- High Performance

## Performance Data:

| Nominal Size | Initial pressure drop @ face velocity | | | CFM Capacity @ face velocity | | |
|---|---|---|---|---|---|---|
| | 300 fpm | 400 fpm | 500 fpm | 300 fpm | 400 fpm | 500 fpm |
| 10 X 20 X 1" | .04 | .07 | .10 | 300 | 400 | 500 |
| 16 X 20 X 1" | .04 | .07 | .10 | 525 | 700 | 875 |
| 16 X 25 X 1" | .04 | .07 | .10 | 671 | 894 | 1118 |
| 20 X 20 X 1" | .04 | .07 | .10 | 675 | 900 | 1125 |
| 20 X 25 X 1" | .04 | .07 | .10 | 863 | 1150 | 1438 |
| 28 X 30 X 1" | .04 | .07 | .10 | 1260 | 1680 | 2100 |
| 28 X 34 X 1" | .04 | .07 | .10 | 1428 | 1904 | 2380 |

# D L MANUFACTURING

## ELECTRONIC AIR CLEANER SPECIFICATIONS




## Features:

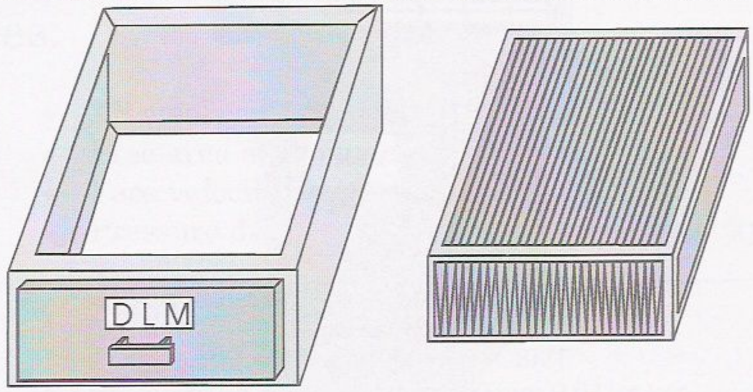
- Lightweight and strong for long service life
- Easy to clean, never needs replacing
- Aluminum pre-filter
- Six standard sizes
- High Performance

## Performance Data:

| Nominal size | CFM | Initial Pressure Drop | Nominal size | CFM | Initial Pressure Drop |
|---|---|---|---|---|---|
| 20 X 12 | 400 | .04 | 28 X 30 | 1000 | .05 |
| | 600 | .07 | | 1200 | .06 |
| | 800 | .13 | | 1400 | .08 |
| | 1000 | .20 | | 1600 | .11 |
| | | | | 1800 | .14 |
| | | | | 2000 | .16 |
| 16 X 25<br>20 X 20 | 600 | .05 | 28 X 34 | 1200 | .04 |
| | 800 | .07 | | 1400 | .06 |
| | 1000 | .09 | | 1600 | .09 |
| | 1200 | .12 | | 1800 | .11 |
| | 1400 | .16 | | 2000 | .14 |
| | | | | 2200 | .16 |
| | | | | 2400 | .18 |
| 20 X 25 | 800 | .04 | | | |
| | 1000 | .06 | | | |
| | 1200 | .07 | | | |
| | 1400 | .10 | | | |
| | 1600 | .13 | | | |
| | 1800 | .16 | | | |
| | 2000 | .20 | | | |

# D L Manufacturing

## PLEATED AIR CLEANER SPECIFICATIONS




## Features:

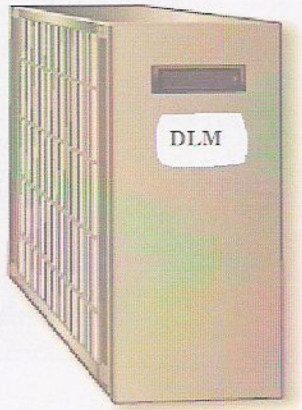
- Very large surface area for long service life
- Quick and easy media replacement
- Six standard sizes
- Very high performance

## Performance Data:

| Nominal size | CFM | Initial Pressure Drop | Nominal size | CFM | Initial Pressure Drop |
|---|---|---|---|---|---|
| 20 X 12 | 400 | .04 | 28 X 30 | 1000 | .05 |
| | 600 | .07 | | 1200 | .06 |
| | 800 | .13 | | 1400 | .08 |
| | 1000 | .20 | | 1600 | .11 |
| | | | | 1800 | .14 |
| | | | | 2000 | .16 |
| 16 X 25<br>20 X 20 | 600 | .05 | 28 X 34 | 1200 | .04 |
| | 800 | .07 | | 1400 | .06 |
| | 1000 | .09 | | 1600 | .09 |
| | 1200 | .12 | | 1800 | .11 |
| | 1400 | .16 | | 2000 | .14 |
| | | | | 2200 | .16 |
| | | | | 2400 | .18 |
| 20 X 25 | 800 | .04 | | | |
| | 1000 | .06 | | | |
| | 1200 | .07 | | | |
| | 1400 | .10 | | | |
| | 1600 | .13 | | | |
| | 1800 | .16 | | | |
| | 2000 | .20 | | | |

# D L Manufacturing

## MERV 10 AND 16 FILTER SPECIFICATIONS




**Model Identification Number**
**HCF 16-10**

Model HCF

Nominal Air Volume
14 = 1400 cfm
16 = 1600 cfm

Filter Efficiency
10 = Merv 10
16 = Merv 16

## Features:

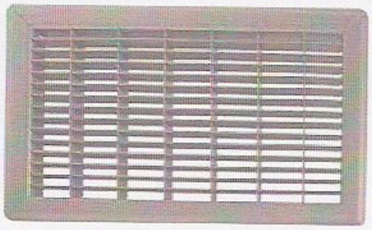
- Very large surface area for long service life
- Quick and easy media replacement
- Six standard sizes
- Very high performance

## Performance Data:

| Airflow CFM | Model Number and Pressure Drop ins w.c. | | | | | |
|---|---|---|---|---|---|---|
| | HCF14-10 | HCF14-16 | HCF16-10 | HCF16-16 | HCF20-10 | HCF20-16 |
| Size | 20 X 20 X 5 | 20 X 20 X 5 | 16 X 25 X 5 | 16 X 25 X 5 | 20 X 25 X 5 | 20 X 25 X 5 |
| 800 | 0.11 | 0.14 | 0.09 | 0.12 | 0.06 | 0.09 |
| 1000 | 0.15 | 0.18 | 0.13 | 0.16 | 0.09 | 0.12 |
| 1200 | 0.20 | 0.24 | 0.17 | 0.21 | 0.12 | 0.15 |
| 1400 | 0.25 | 0.29 | 0.21 | 0.25 | 0.15 | 0.19 |
| 1600 | N/R | N/R | 0.27 | 0.31 | 0.18 | 0.23 |
| 1800 | N/R | N/R | N/R | N/R | 0.22 | 0.27 |
| 2000 | N/R | N/R | N/R | N/R | 0.27 | 0.31 |

Note: N/R = Not recommended

# RETURN AIR FLOOR GRILL SPECIFICATIONS



## Features:

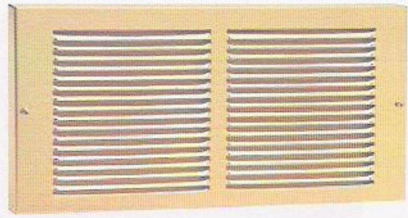
- All steel construction
- Free area approximately 80%
- Face velocity at 400 fpm
- Pressure drop at 0.02 ins w.c. for face velocity of 400 fpm only

FREE AREA OF TRUSSED STEEL
**FLOOR GRILLES**
IN RELATION TO NOMINAL SIZE
Average pressure drop of grille at 400 fpm 0.02 ins w.c.

| NOMINAL GRILLE SIZE | FREE AREA (SQ/INS) | NOMINAL GRILLE SIZE | FREE AREA (SQ/INS) |
|---|---|---|---|
| 4 X 10 | 34 | 12 X 12<br>6 X 24 | 119 |
| 4 X 12<br>6 X 8 | 40 | 6 X 30<br>10 X 18 | 145 |
| 6 X 10 | 52 | 8 X 24<br>12 X 16 | 157 |
| 6 X 12<br>4 X 18 | 62 | 8 X 30<br>10 X 24<br>12 X 20 | 187 |
| 8 X 10<br>4 X 18 | 69 | 14 X 20<br>12 X 24 | 209 |
| 6 X 14 | 72 | 10 X 30 | 223 |
| 8 X 12<br>6 X 16<br>4 X 24 | 82 | 14 X 24 | 256 |
| 8 X 14<br>6 X 18 | 95 | 12 X 30 | 279 |
| 10 X 12<br>6 X 20<br>4 X 30 | 101 | 14 X 30 | 328 |
| | | 24 X 24 | 446 |

Note: 1) To find the required free area for a grille, consult the table and or formula found in Appendix C (C8)

# RETURN AIR WALL GRILL SPECIFICATIONS



## Features:

- All steel construction
- Free area approximately 80%
- Face velocity at 400 fpm
- Pressure drop at 0.02 ins w.c. for face velocity of 400 fpm only

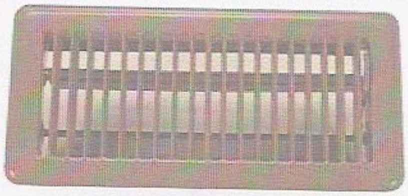
FREE AREA OF STEEL
**WALL GRILLES**
IN RELATION TO NOMINAL SIZE
Average pressure drop of grille at 400 fpm 0.02 ins w.c.

| NOMINAL GRILLE SIZE | Ak | FREE AREA (SQ/INS) | NOMINAL GRILLE SIZE | Ak | FREE AREA (SQ/INS) |
|---|---|---|---|---|---|
| 6 X 6 | 0.20 | 29 | 10 X 10 | 0.58 | 84 |
| 10 X 4 | 0.22 | 32 | 18 X 6 | 0.64 | 92 |
| 8 X 6<br>12 X 4 | 0.28 | 41 | 14 X 8 | 0.67 | 97 |
| 10 X 6 | 0.35 | 51 | 20 X 6<br>12 X 10<br>30 X 4 | 0.71 | 102 |
| 8 X 8<br>16 X 4 | 0.39 | 56 | 20 X 8 | 0.97 | 139 |
| | | | 24 x 6 | 0.82 | 115 |
| 12 X 6<br>18 X 4 | 0.42 | 61 | 18 X 10<br>30 X 6 | 1.06 | 153 |
| 10 X 8<br>20 X 4 | 0.49 | 70 | 24 X 8 | 1.16 | 167 |
| 14 X 6 | 0.49 | 71 | 30 X 8 | 1.45 | 209 |
| 12 X 8<br>16 X 6<br>24 X 4 | 0.58 | 84 | 30 X 10 | 1.75 | 252 |

Note: 1) To find the required free area for a grille, consult the table and or formula found in Appendix C (C8)

Note: 2) This chart can be used for both high and or low wall supply diffusers of similar style with single blade damper.

# SUPPLY AIR FLOOR DIFFUSER SPECIFICATIONS



## Features:

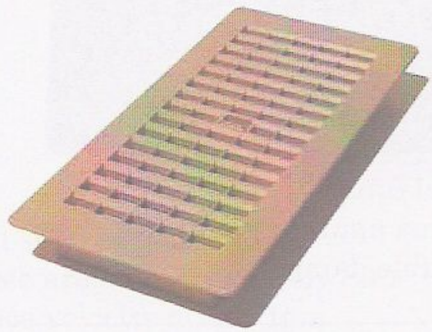
- All steel construction
- Free area approximately 60%
- Adjustable damper

Technical Data for
Pressed Steel Floor Diffusers
With Blade type damper

| Size | Free Area | Performance | 0 – 49 CFM | 50 – 69 CFM | 70 – 89 CFM | 90 – 109 CFM | 110 – 120 CFM |
|---|---|---|---|---|---|---|---|
| 2-1/4 X 10 | 13 | Pressure | 0.02 | 0.03 | | | |
| | | Spread | 6.0 | 8.0 | | | |
| | | Throw | 4.0 | 5.5 | | | |
| | | Velocity | 444 | 667 | | | |
| 2-1/4 X 12 | 16 | Pressure | 0.01 | 0.02 | 0.04 | | |
| | | Spread | 4.5 | 7.0 | 9.0 | | |
| | | Throw | 4.0 | 5.5 | 7.0 | | |
| | | velocity | 364 | 545 | 727 | | |
| 3 X 10 | 20 | Pressure | 0.01 | 0.02 | 0.02 | 0.04 | |
| | | Spread | 3.8 | 5.4 | 7.6 | 9.5 | |
| | | Throw | 3.2 | 4.1 | 6.0 | 8.0 | |
| | | velocity | 286 | 429 | 571 | 714 | |
| 4 X 10 | 24 | Pressure | 0.005 | 0.01 | 0.01 | 0.02 | 0.03 |
| | | Spread | 3.9 | 5.5 | 7.5 | 9.5 | 11.0 |
| | | Throw | 3.0 | 4.5 | 6.9 | 7.5 | 9.0 |
| | | velocity | 235 | 353 | 471 | 588 | 706 |
| 4 X 12 | 29 | Pressure | | 0.01 | 0.01 | 0.02 | 0.02 |
| | | Spread | | 5.0 | 6.5 | 8.0 | 9.5 |
| | | Throw | | 4.0 | 5.5 | 7.0 | 8.0 |
| | | velocity | | 300 | 400 | 500 | 600 |

Note: pressure = the pressure loss (drop) created by the diffuser
spread = the total width in feet of the air pattern at terminal velocity
throw = the vertical distance in feet the air travels to reach terminal velocity
velocity = the face velocity at the diffuser in feet per minute

# SUPPLY AIR FLOOR DIFFUSER SPECIFICATIONS



## Features:

- All PVC construction
- Free area approximately 60%
- Adjustable damper

| Size | Area (Ak) | Performance | 40 CFM | 60 CFM | 80 CFM | 100 CFM | 120 CFM | 140 CFM |
|---|---|---|---|---|---|---|---|---|
| 2-1/4 X 10 | 0.13 | Ps | 0.015 | 0.026 | 0.043 | 0.067 | | |
| | | Spread | 6.0 | 8.0 | 10.0 | 12.0 | | |
| | | Throw | 4.0 | 5.5 | 8.0 | 9.4 | | |
| | | Vk | 317 | 476 | 635 | 793 | | |
| 2-1/4 X 12 | 0.15 | Ps | 0.012 | 0.022 | 0.038 | 0.059 | 0.084 | |
| | | Spread | 4.5 | 7.0 | 9.0 | 11.0 | 13.3 | |
| | | Throw | 4.0 | 5.5 | 7.0 | 9.0 | 10.1 | |
| | | Vk | 267 | 400 | 533 | 667 | 800 | |
| 3 X 10 | 0.14 | Ps | 0.012 | 0.028 | 0.050 | 0.078 | 0.113 | 0.155 |
| | | Spread | 3.8 | 5.4 | 7.6 | 9.5 | 12.0 | 14.0 |
| | | Throw | 3.2 | 4.1 | 6.0 | 8.0 | 9.9 | 12.0 |
| | | Vk | 284 | 427 | 569 | 711 | 853 | 996 |
| 4 X 10 | 0.21 | Ps | | 0.022 | 0.031 | 0.044 | 0.059 | 0.079 |
| | | Spread | | 5.5 | 7.5 | 9.5 | 11.0 | 13.0 |
| | | Throw | | 4.5 | 6.9 | 7.5 | 9.0 | 10.5 |
| | | Vk | | 288 | 383 | 479 | 575 | 671 |
| 4 X 12 | 0.29 | Ps | | 0.013 | 0.020 | 0.028 | 0.037 | 0.049 |
| | | Spread | | 5.0 | 6.5 | 8.0 | 9.5 | 11.5 |
| | | Throw | | 4.0 | 5.5 | 7.0 | 8.0 | 9.5 |
| | | Vk | | 211 | 281 | 351 | 421 | 491 |

Note: Ps = the pressure loss (drop) created by the diffuser
spread = the total width in feet of the air pattern at terminal velocity
throw = the vertical distance in feet the air travels to reach terminal velocity
Vk = the face velocity at the diffuser in feet per minute
Ak = the free area of the diffuser opening expressed as a decimal of a sq/ft

# SUPPLY AIR CEILING DIFFUSER SPECIFICATIONS

## Features:

- All PVC construction
- Free area approximately 60%
- Adjustable damper

| TECHNICAL DATA FOR ROUND CEILING DIFFUSERS | | | | | | |
|---|---|---|---|---|---|---|
| Size | Free Area | Performance | 0 – 59 CFM | 60 – 89 CFM | 90 – 109 CFM | 110 – 125 CFM |
| 6 | 20 | pressure<br>throw<br>velocity | 0.01<br>1.9<br>357 | 0.02<br>3.1<br>535 | 0.04<br>3.9<br>714 | |
| 8 | 36 | pressure<br>throw<br>velocity | | 0.01<br>1.8<br>313 | 0.01<br>3.0<br>417 | 0.02<br>4.2<br>660 |
| 10 | 52 | pressure<br>throw<br>velocity | | | 0.01<br>2.4<br>208 | 0.01<br>3.6<br>417 |

Note: pressure = the pressure loss (drop) created by the diffuser
throw = the horizontal distance in feet the air travels to reach terminal velocity
velocity = the face velocity at the diffuser in feet per minute

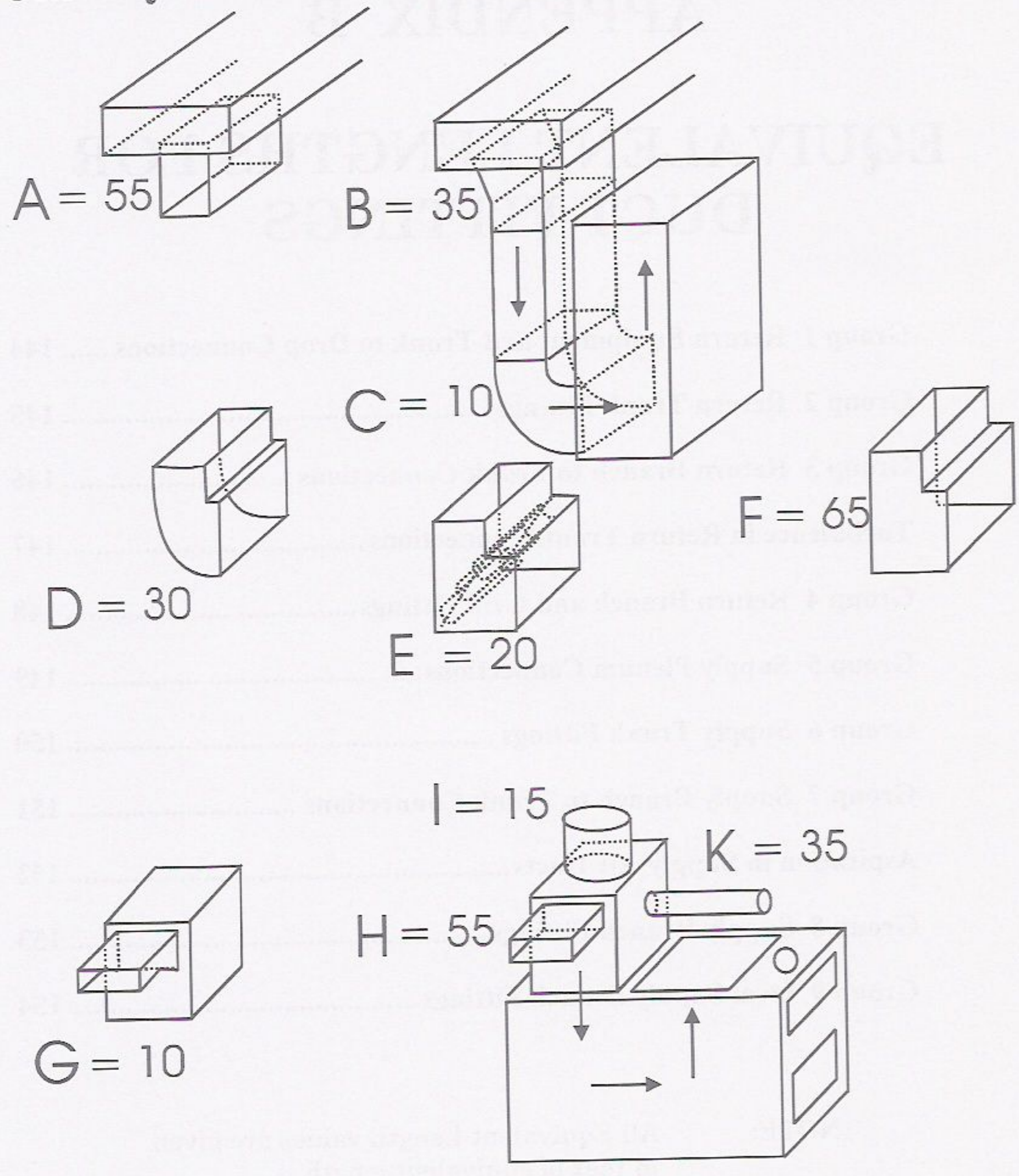
# APPENDIX B

# EQUIVALENT LENGTHS FOR DUCT FITTINGS



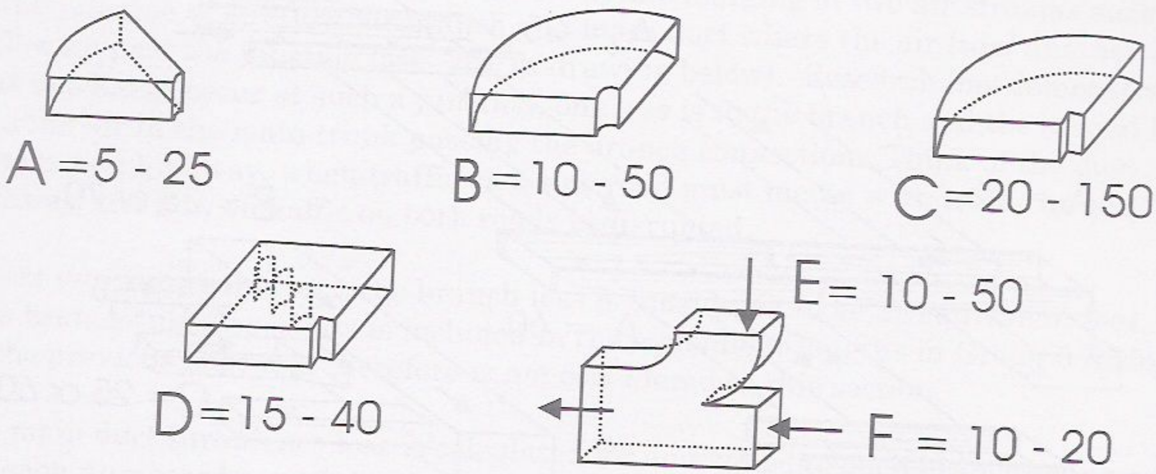
NOTE: All Equivalent Length values are given in feet of equivalent length.

## GROUP 1
## RETURN EQUIPMENT AND TRUNK TO DROP CONNECTIONS

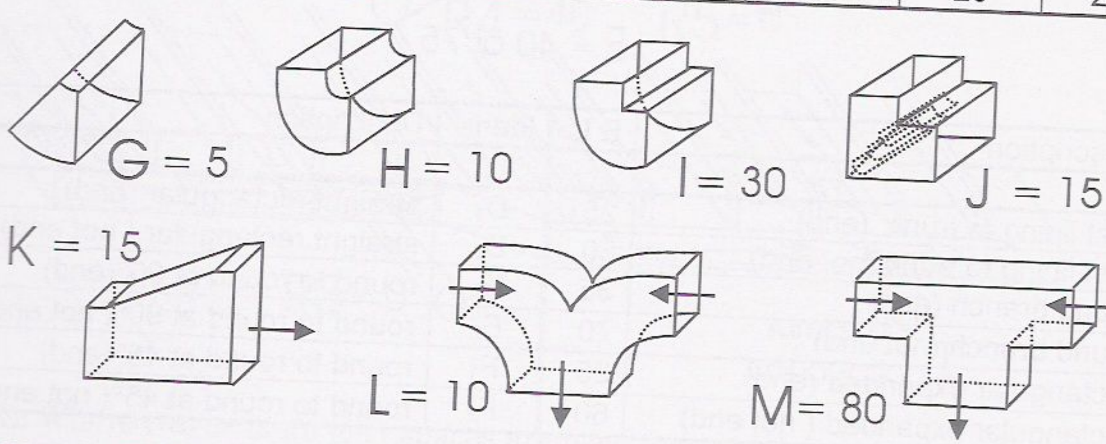



| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| A | straight duct drop | 55 | F | rect elbow (no turning vanes) | 65 |
| B | expanded collar drop | 35 | G | expanded collar to plenum | 10 |
| C | elbow (min. throat radius 1/2 width) | 10 | H | rectangular duct with turn | 55 |
| D | elbow with square throat | 30 | I | round duct no turn | 15 |
| E | rect. elbow with turning vanes | 20 | J | round duct with turn | 35 |

# GROUP 2
## RETURN TRUNK FITTINGS

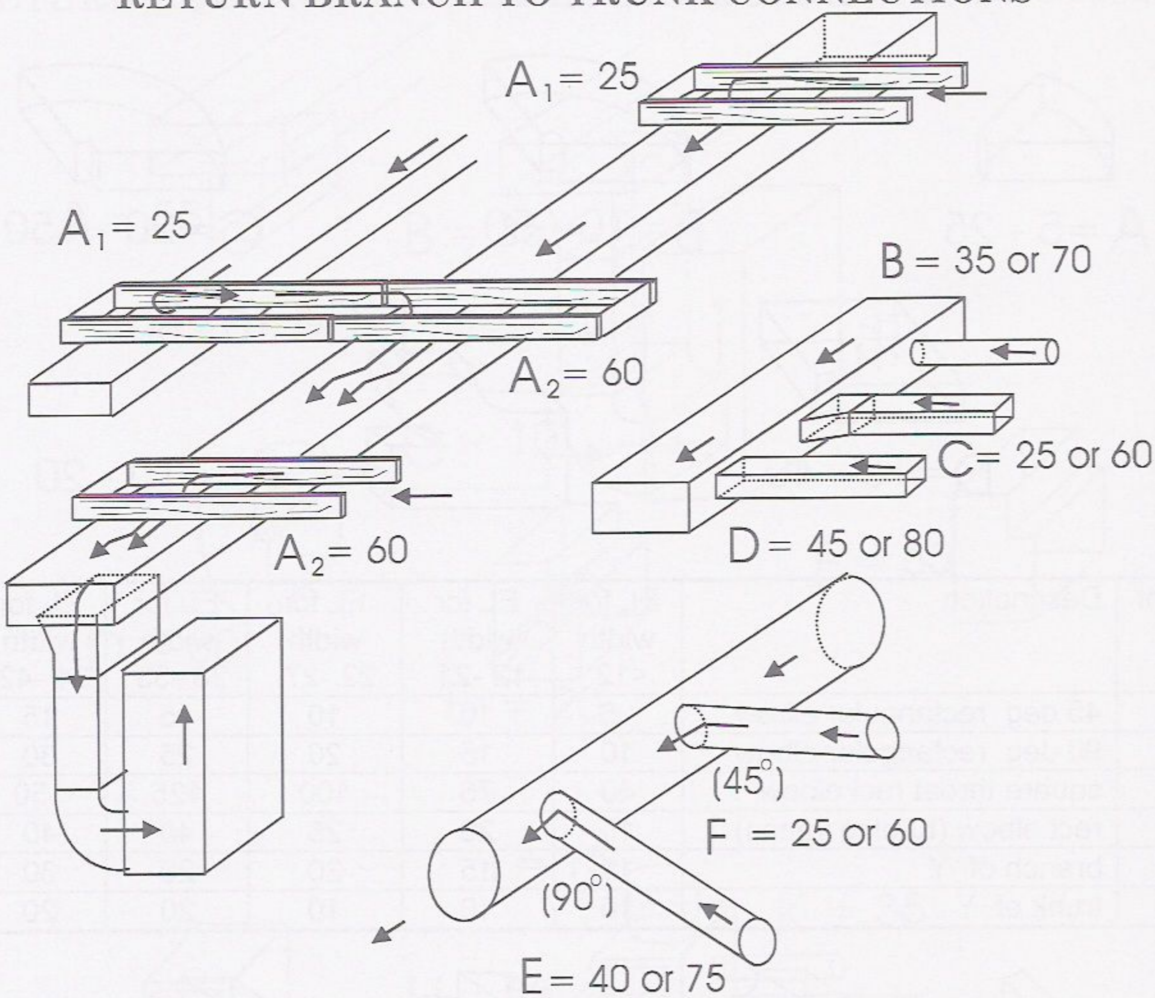



| Ident | Description | EL for width <12 | EL for width 12 -21 | EL for width 22 -27 | EL for width 28 -33 | EL for width 34 -42 | EL for width > 42 |
|---|---|---|---|---|---|---|---|
| A | 45 deg rectangular elbow | 5 | 10 | 10 | 15 | 15 | 25 |
| B | 90 deg rectangular elbow | 10 | 15 | 20 | 25 | 30 | 50 |
| C | square throat rect elbow | 40 | 75 | 100 | 125 | 150 | --- |
| D | rect elbow (turning vanes) | 15 | 20 | 25 | 40 | 40 | --- |
| E | branch of Y | 10 | 15 | 20 | 20 | 30 | 50 |
| F | trunk of Y | 10 | 10 | 10 | 20 | 20 | 20 |




| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| G | 45 deg rectangular elbow | 5 | J | rect elbow (turning vanes) | 15 |
| H | 90 deg rectangular elbow | 10 | K | transition | 15 |
| I | square throat round heel elbow | 30 | L | tee ( each branch) | 10 |
| | | | M | rectangular tee (each branch) | 80 |

# GROUP 3
# RETURN BRANCH TO TRUNK CONNECTIONS




| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| | | | | | |
| $A_1$ | joist lining to trunk (end) | 25 | $D_1$ | straight rectangular (end) | 45 |
| $A_2$ | joist lining to trunk (not end) | 60 | $D_2$ | straight rectangular ( not end) | 80 |
| $B_1$ | round branch (end) | 35 | $E_1$ | round to round at 90°(end) | 40 |
| $B_2$ | round branch (not end) | 70 | $E_2$ | round to round at 90°( not end) | 75 |
| $C_1$ | rectangular expanded (end) | 25 | $F_1$ | round to round at 45°(end) | 25 |
| $C_2$ | rectangular expanded ( not end) | 60 | $F_2$ | round to round at 45°( not end) | 60 |

NOTE: The difference between 1 and 2 is caused by disturbance of laminar air flow when two airstreams meet.

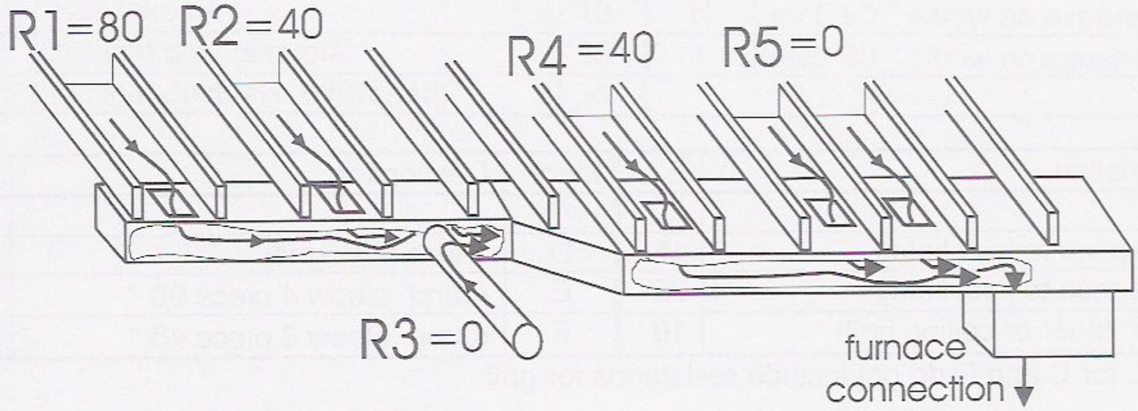
# TURBULENCE IN RETURN TRUNK CONNECTIONS

Turbulence is a form of resistance caused by the merging of two air streams such as at the junction of a return air branch and main duct where the air from another inlet is flowing past the junction (see "R2" in drawing below). Research has demonstrated that two losses occur at such a junction, one loss is to the branch and the second loss is to the air in the main trunk passing the branch connection. Think of the duct system as a highway, when traffic on a side road must merge with traffic on the highway, the flow of traffic on both roads is disrupted.

Where two airstreams mix, the branch loss is considered to be 35 equivalent feet. This branch turbulence loss is included in the equivalent lengths in Group 3 fittings on the previous page and therefore is not considered in this section.

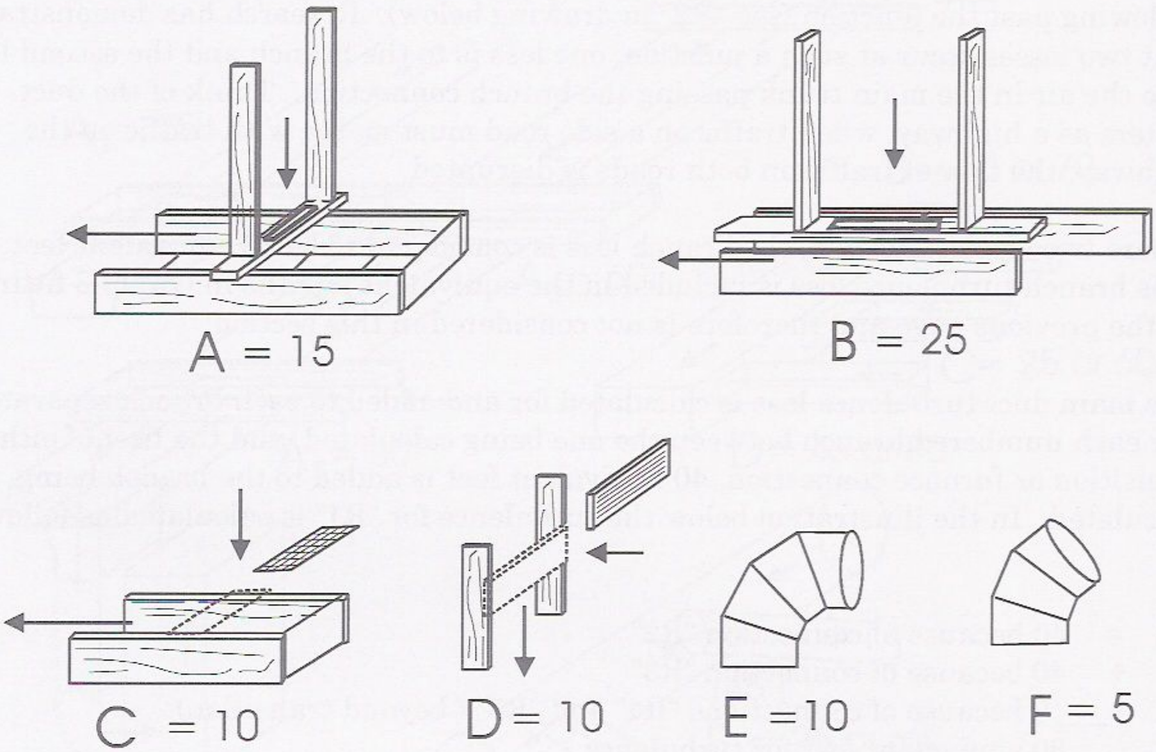
The main duct turbulence loss is calculated for and added to each branch separately. For each numbered branch between the one being calculated, and the first of either a transition or furnace connection, 40 equivalent feet is added to the branch being calculated. In the illustration below the turbulence for "R1" is calculated as follows:

R1 = 40 because of connection "R2"
+ 40 because of connection "R3"
+ 0 because of connections "R4" and "R5" ( beyond transition)
80 equivalent feet for turbulence




NOTE: Where two or more joist spaces are used for a single return opening, they are deemed to be one connection for the purpose of turbulence calculations. In the illustration above, turbulence added to "R4" is calculated using a value of 40 equivalent feet for R5, even though R5 enters the main duct as two openings.

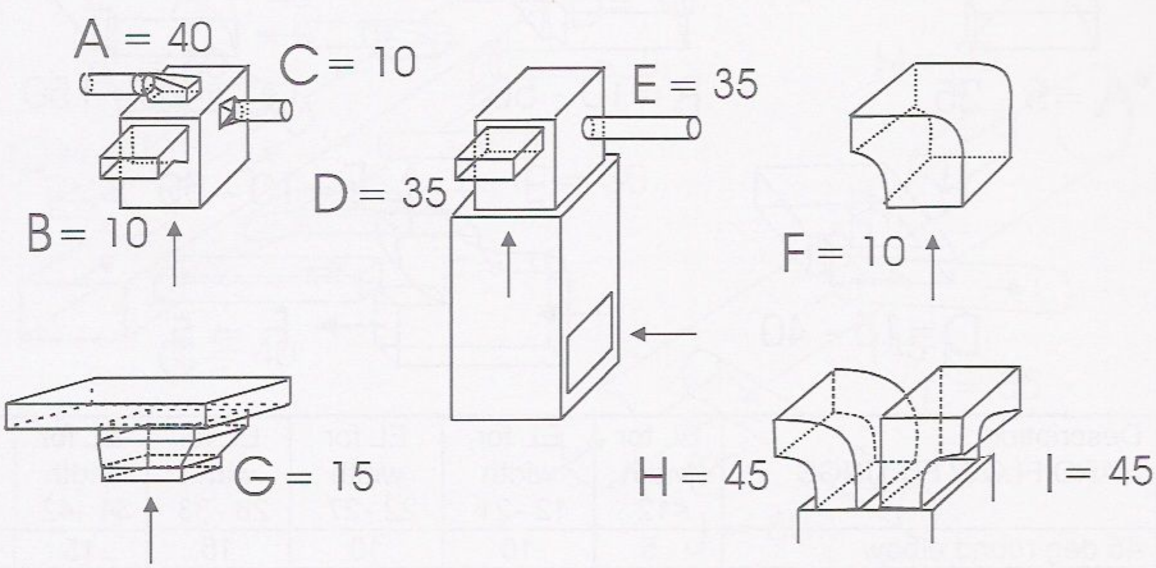
# GROUP 4
# RETURN BRANCH AND GRILL FITTINGS




| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| | | | | | |
| A | stud space to joist lining | 15 | D | 1 turn (wall grill) | 10 |
| B | stud space to joist lining | 25 | E | round elbow 4 piece 90 ° | 10 |
| C | 1 turn (floor or ceiling grill) | 10 | F | round elbow 3 piece 45 ° | 5 |

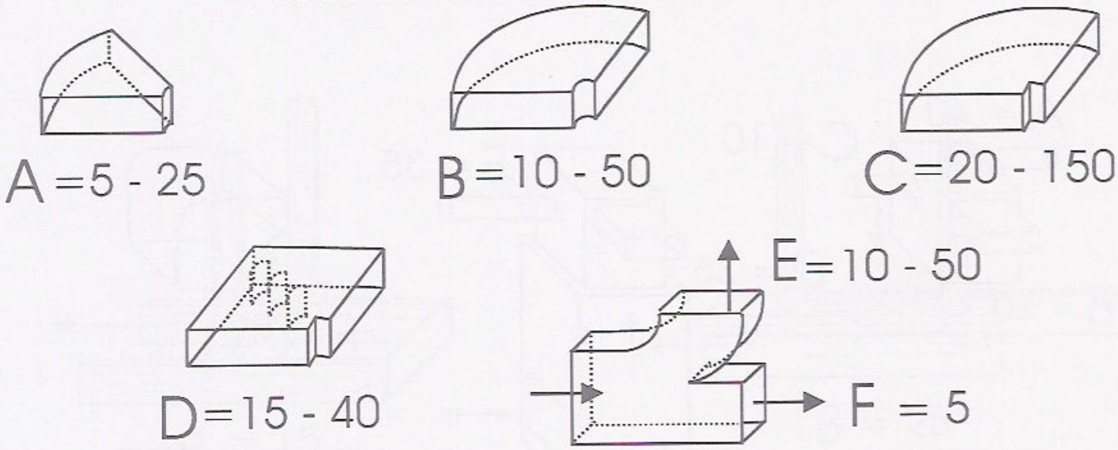
Note: EL for C and D do not include resistance for grill

# GROUP 5
# SUPPLY PLENUM CONNECTIONS

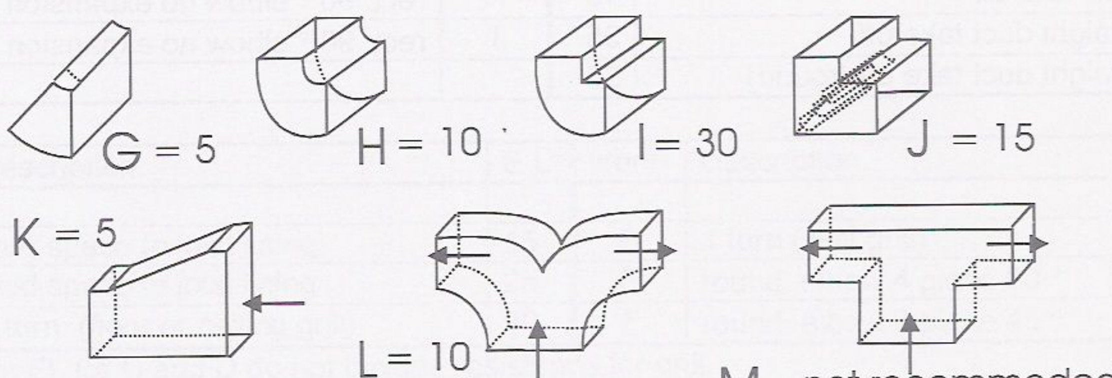



| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| A | top take off | 40 | F | change elbow 10 min throat rad | 10 |
| B | expanded collar increased by 1.5 | 10 | G | restricted head room transition | 15 |
| C | side take off | 10 | H | rect. 90 ° elbow no expansion | 45 |
| D | straight duct take off | 35 | I | rect. 90 ° elbow no expansion | 45 |
| E | straight duct take off (round) | 35 | | | |

# GROUP 6
# SUPPLY TRUNK FITTINGS

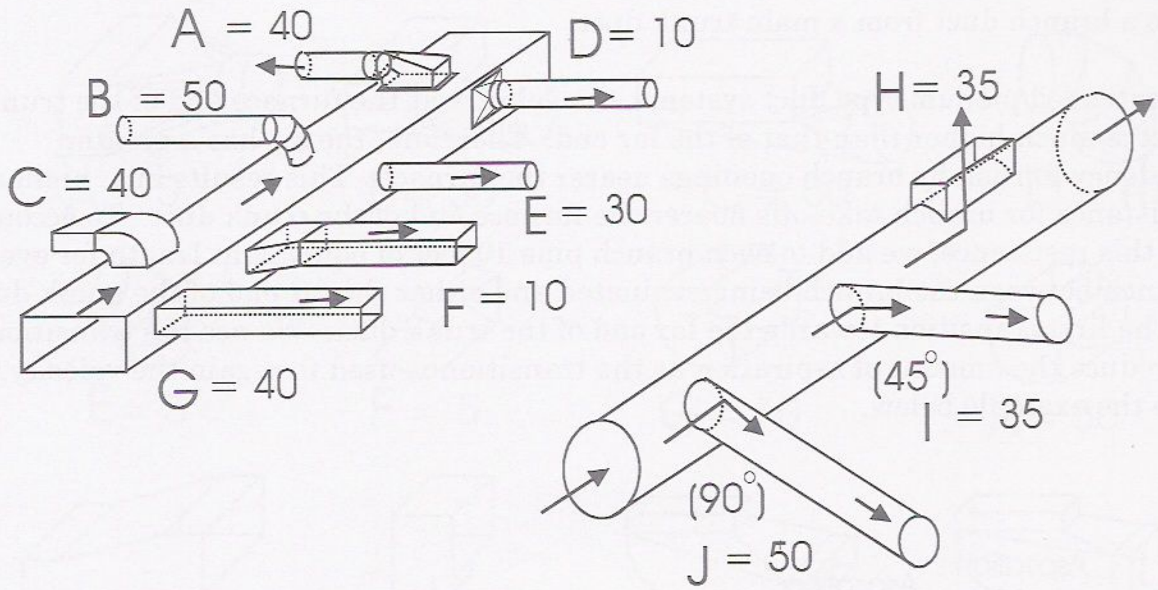



| Ident | Description<br>HARD FLOW FITTINGS | EL for width <12 | EL for width 12 -21 | EL for width 22 -27 | EL for width 28 -33 | EL for width 34 -42 | EL for width > 42 |
|---|---|---|---|---|---|---|---|
| A | 45 deg round elbow | 5 | 10 | 10 | 15 | 15 | 25 |
| B | 90 deg round elbow | 10 | 15 | 20 | 25 | 30 | 50 |
| C | square throat round elbow | 40 | 75 | 100 | 125 | 150 | --- |
| D | square elbow turning vanes | 15 | 20 | 25 | 40 | 40 | --- |
| E | branch of Y | 10 | 15 | 20 | 20 | 30 | 50 |
| F | trunk of Y | 5 | 5 | 5 | 5 | 5 | 5 |




| Ident | Description<br>EASY FLOW FITTINGS | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| G | 45 deg rectangular elbow | 5 | J | rect. elbow (turning vanes) | 15 |
| H | 90 deg rectangular elbow | 10 | K | transition | 5 |
| I | square throat round heel elbow | 30 | L | tee ( each branch) | 10 |
| | | | M | rect. tee (each branch) | --- |

# GROUP 7
# SUPPLY TRUNK TO BRANCH CONNECTIONS

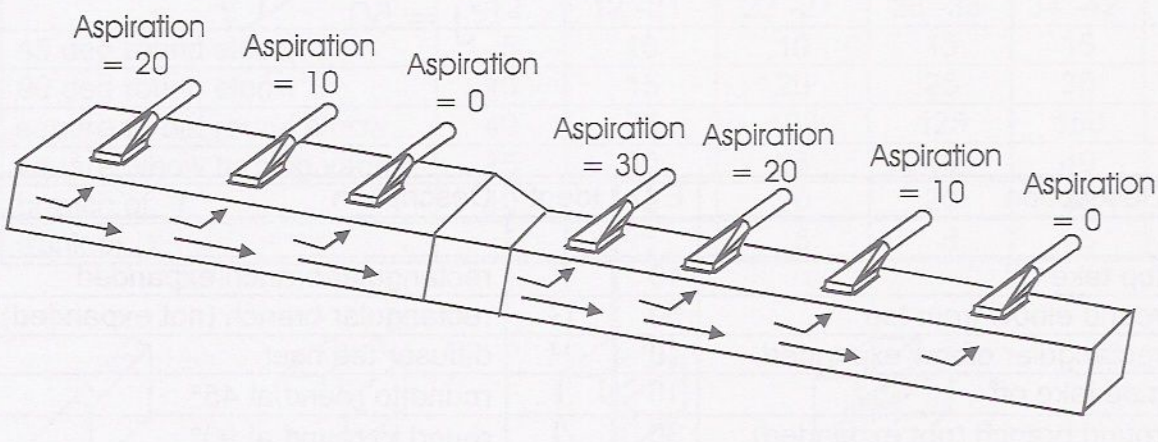



| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| | | | | | |
| A | top take off | 40 | F | rectangular branch expanded | 10 |
| B | round elbow from top | 50 | G | rectangular branch (not expanded) | 40 |
| C | rectangular elbow expanded | 40 | H | diffuser tee riser | 35 |
| D | side take off | 10 | I | round to round at 45° | 35 |
| E | round branch (not expanded) | 30 | J | round to round at 90° | 50 |

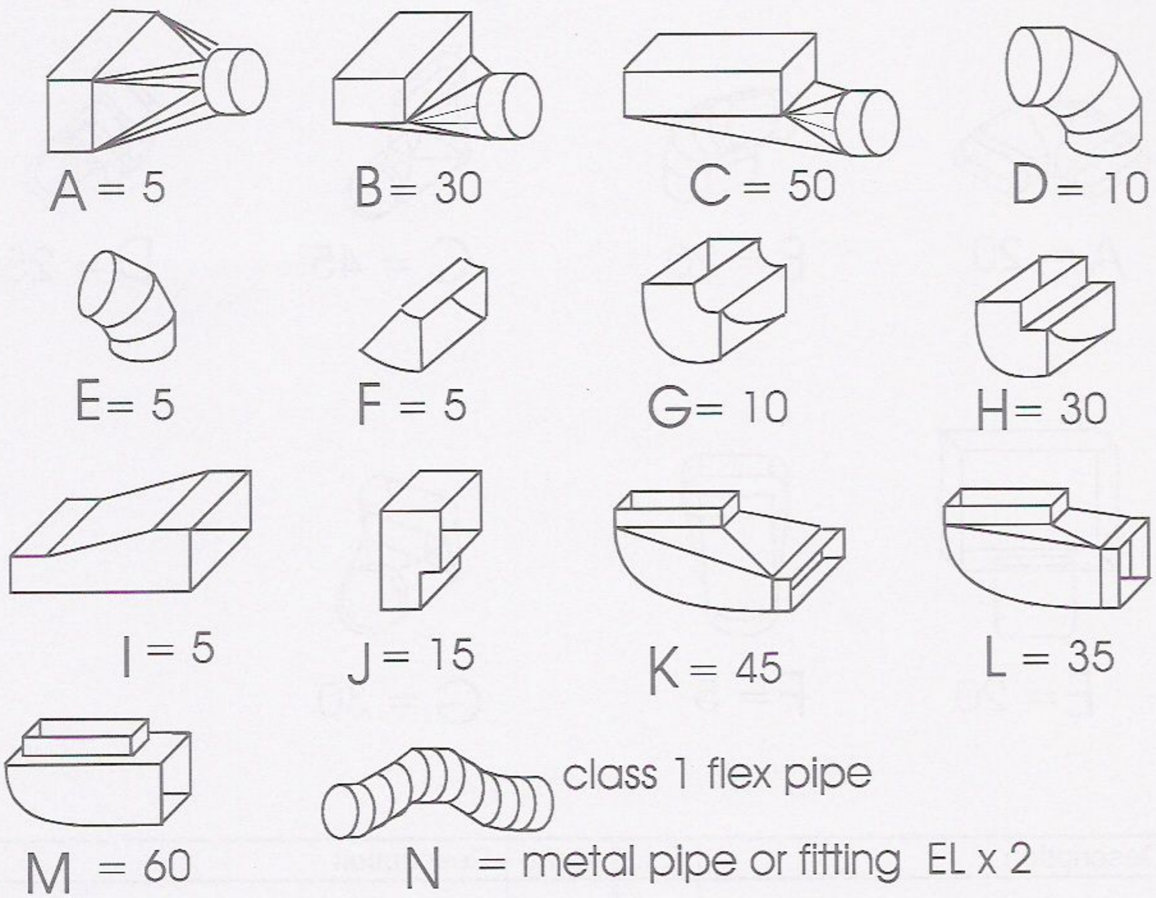
## ASPIRATION IN SUPPLY AIR DUCTS

Aspiration is the negative effect velocity has on the ability of rushing air to enter into a branch duct from a main trunk duct.

In extended plenum type duct systems, the velocity at the furnace end of the trunk duct is much higher than that of the far end. Therefore, the air has a greater tendency to rush by branch openings nearer the furnace. This results in a higher resistance for branch take-offs nearer the furnace end of the trunk duct. To account for this resistance, we add to each branch pipe 10 feet of equivalent length for every branch between the branch being evaluated and either the far end of the trunk duct or the first transition towards the far end of the trunk duct. We use the transition to reduce the amount of aspiration as the transition is used to regain the velocity. See the example below.

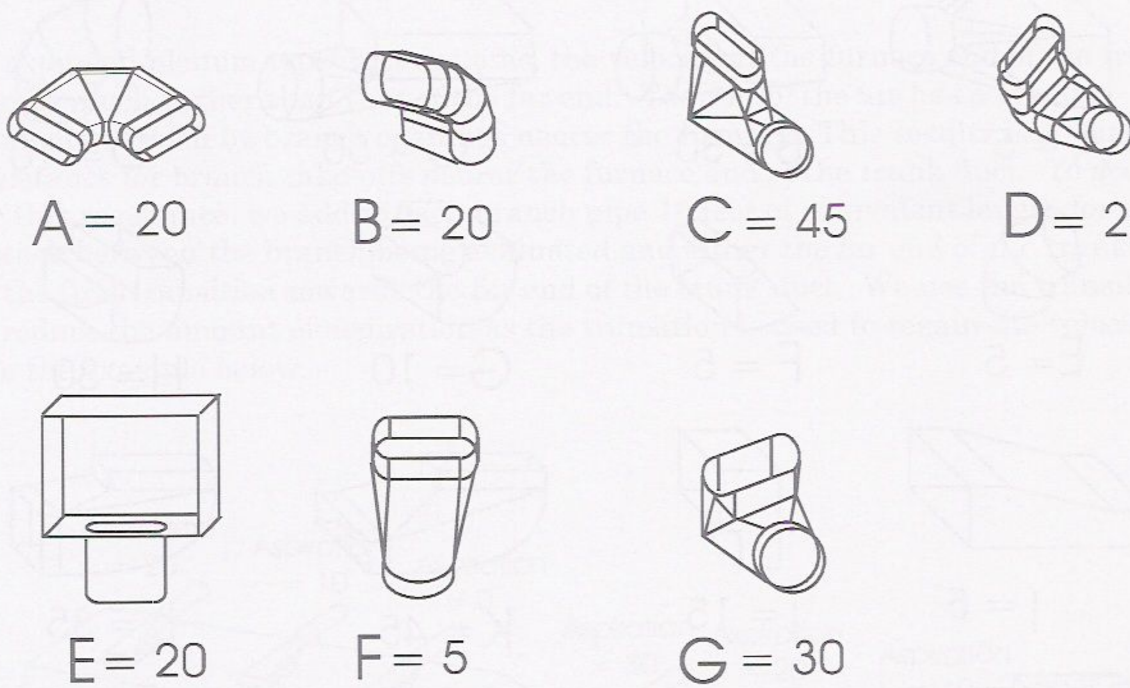


## GROUP 8
## SUPPLY BRANCH FITTINGS




| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| | | | | | |
| A | universal boot | 5 | H | 90° rectangular elbow (sq throat) | 30 |
| B | angle (broadway) boot | 30 | I | straight stack head | 5 |
| C | end boot | 50 | J | 90° stack head | 15 |
| D | 90° 4 piece adjustable elbow | 10 | K | change elbow (rec to rec) | 45 |
| E | 45° 3 piece adjustable elbow | 5 | L | change elbow (sq to rec) | 30 |
| F | 45° rectangular elbow | 5 | M | diffuser riser no expansion | 60 |
| G | 90° rectangular elbow | 10 | N | class 1 flex duct or fitting | x 2 |

# GROUP 9
# OVAL SUPPLY BRANCH FITTINGS

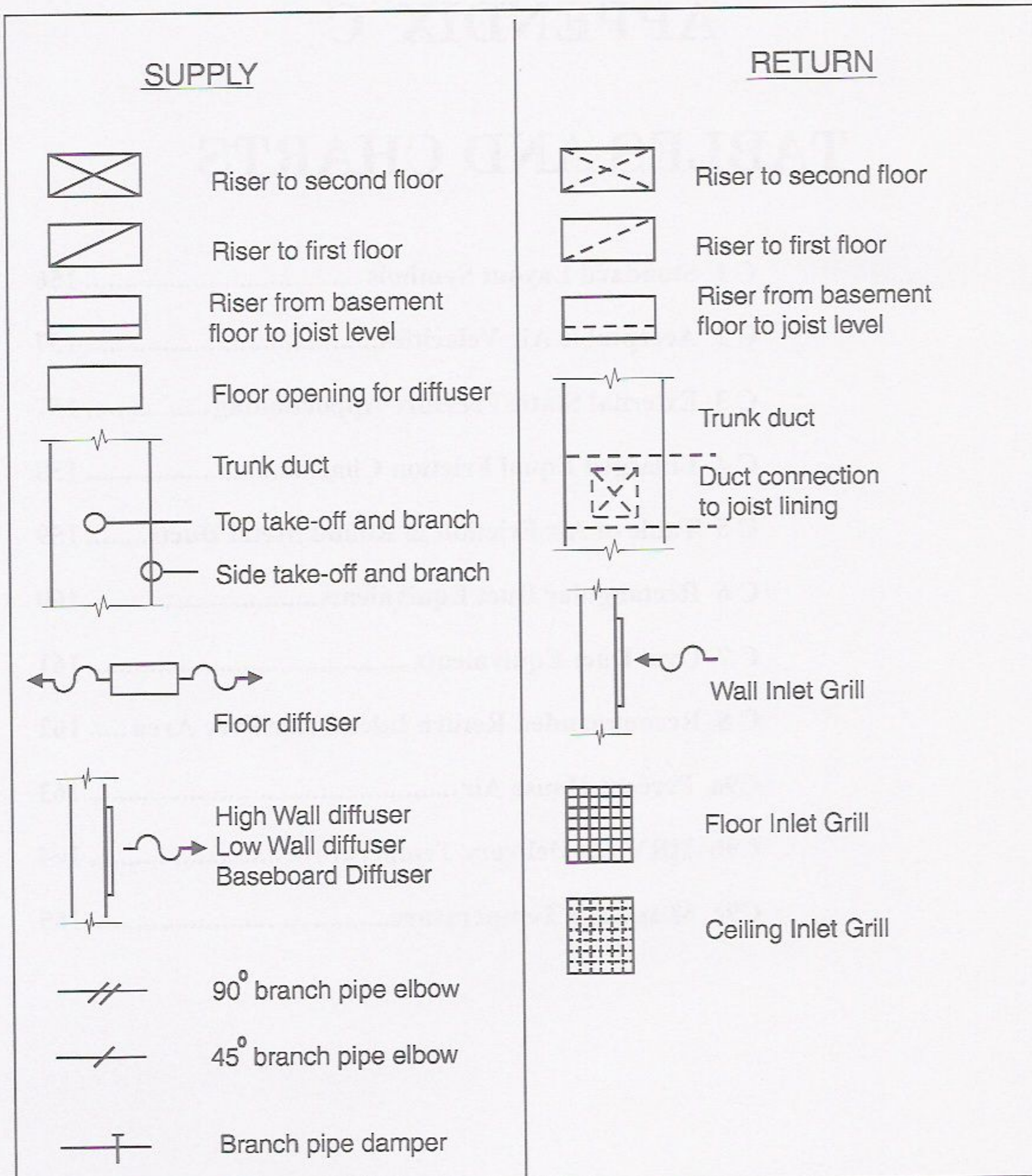



| Ident | Description | E L | Ident | Description | E L |
|---|---|---|---|---|---|
| | | | | | |
| A | 90° 4 piece elbow (flat) | 20 | E | 90° stack head | 20 |
| B | 90° 4 piece elbow | 20 | F | round to oval transition | 5 |
| C | round to oval end boot | 50 | G | ventilation stack head | 30 |
| D | round to oval broadway boot | 25 | | | |

# APPENDIX C

# TABLES AND CHARTS

# C1 - STANDARD LAYOUT SYMBOLS




## ABBREVIATIONS

| | | | | | |
|---|---|---|---|---|---|
| S.S. | Stud space used for return duct | Th. | Thermostat | Clg. | Ceiling |
| J.S. | Joist space used as return duct | B.B. | Baseboard | Fl. | Floor |
| D | Damper | L.W. | Low wall | R.A. | Return air |
| CFM | Cubic feet per minute | H. W. | High wall | S.A. | Supply Air |

## C2 - ACCEPTABLE AIR VELOCITIES (fpm) (IN RESIDENTIAL DUCT SYSTEMS)

| Type of duct | SUPPLY | | RETURN | |
|---|---|---|---|---|
| | recommended | maximum | recommended | maximum |
| Main duct | 700 | 900 | 600 | 700 |
| Branch duct | 600 | 750 | 600 | 650 |
| Registers Diffusers & Grills face velocity | 500 | 750 | 400 | 600 |
| Filter Grill face velocity | | | | 300 |

## C3 - DESIGN PRESSURE APPORTIONING

| Longest Return Air Effective length | Decimal part of design pressure to be apportioned | |
|---|---|---|
| | Return | Supply |
| 114 ft. or less | .25 | .75 |
| 115 ft. to 190 ft. | .40 | .60 |
| 191 ft. to 300 ft. | .50 | .50 |
| 301 ft or more | See note below | |

NOTE: 1) This table should be used as a guide only. Designer may vary apportioning to improve design.

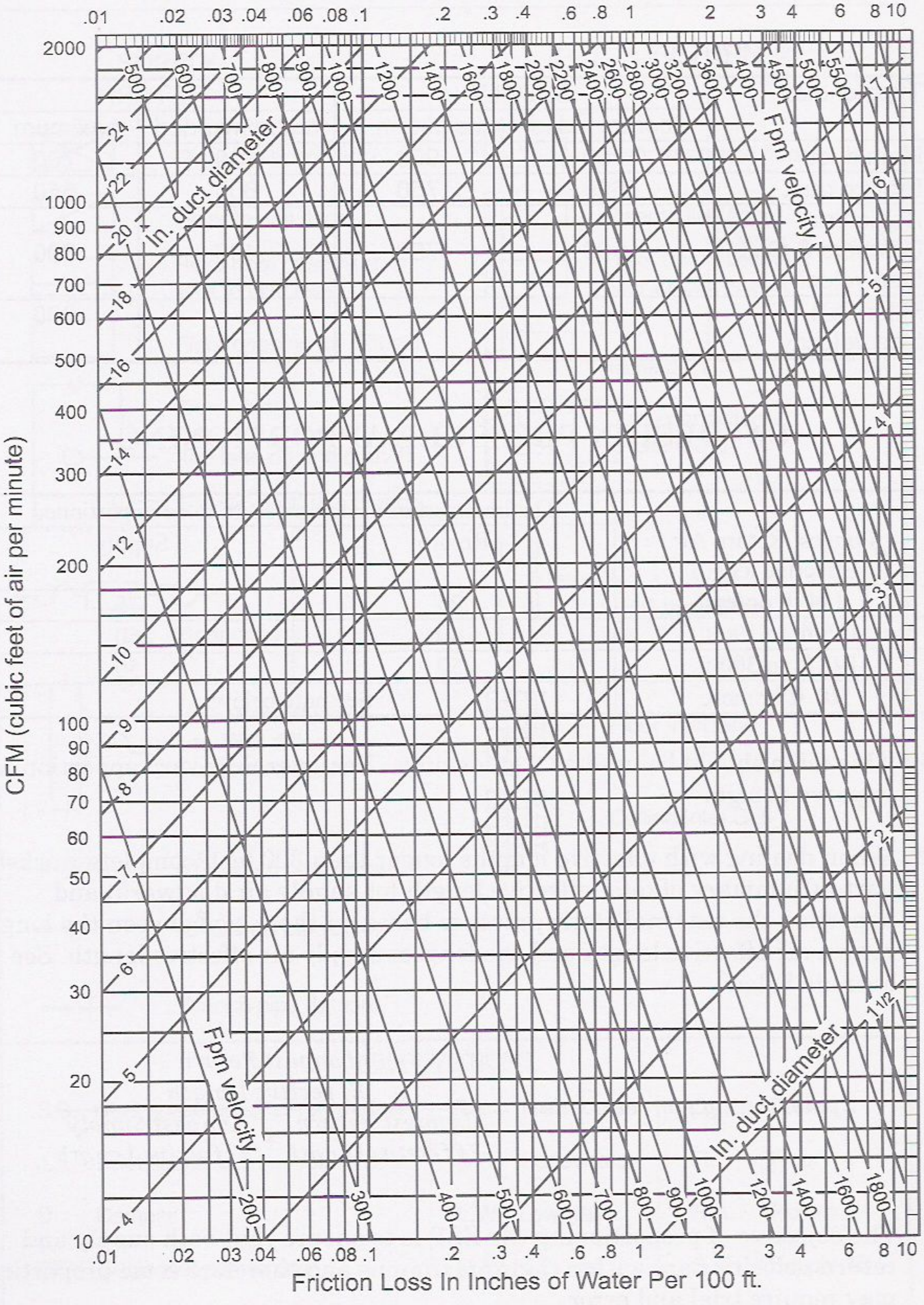
NOTE: 2) When dealing with effective lengths longer than 300 feet, complete worksheet part I (Summary of total effective length for supply air ductwork) and apportion the external static pressure based on the ratio between the longest return air effective length and the longest supply air effective length. See formula below.

$$\textit{Apportioning for return duct} = \frac{\begin{matrix}\textit{Longest Return}\\ \textit{Effective Length}\end{matrix}}{\begin{matrix}\textit{Longest Return}\\ \textit{Effective Length}\end{matrix} + \begin{matrix}\textit{Longest Supply}\\ \textit{Effective Length}\end{matrix}}$$

The objective of proportioning the ESP is to ensure that both supply and return velocities are within their maximums and therefore some proportioning may require trial and error.

# C4 - ENLARGED EQUAL FRICTION CHART

Round Galvanized Metal Duct (10 CFM to 2000 CFM)



# C5 – TABLE OF AIR FRICTION IN ROUND METAL DUCTS

To find the duct size:

1. enter the top of the table under the column listing appropriate friction loss rate
2. move down the column until required CFM is listed
3. move horizontally left and read the nearest duct size on left side of table

Notes: A branch pipe size greater than .3" is rounded up to the next largest standard pipe size. A trunk pipe size is rounded to the nearest 1/2 inch
Staggered heavy lines define air velocity (FPM)

500

| Size | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 | 0.16 | 0.18 | 0.20 | 0.25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.0 | | | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 23 | 26 |
| 3.5 | 10 | 13 | 15 | 17 | 19 | 21 | 22 | 24 | 25 | 27 | 28 | 29 | 31 | 32 | 33 | 35 | 37 | 42 |
| 4.0 | 15 | 19 | 22 | 25 | 28 | 31 | 33 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 49 | 52 | 55 | 63 |
| 4.5 | 21 | 26 | 31 | 35 | 39 | 42 | 46 | 49 | 52 | 54 | 57 | 60 | 63 | 65 | 68 | 72 | 76 | 87 |
| 5.0 | 26 | 33 | 39 | 44 | 49 | 54 | 58 | 62 | 66 | 70 | 74 | 78 | 81 | 84 | 88 | 94 | 100 | 114 |
| 5.5 | 34 | 48 | 50 | 57 | 64 | 70 | 75 | 81 | 86 | 90 | 96 | 100 | 104 | 108 | 112 | 120 | 126 | 144 |
| 6.0 | 41 | 53 | 62 | 71 | 79 | 86 | 93 | 99 | 105 | 111 | 117 | 123 | 128 | 133 | 138 | 148 | 156 | 177 |
| 6.5 | 54 | 68 | 80 | 90 | 100 | 109 | 118 | 125 | 131 | 140 | 146 | 153 | 160 | 165 | 171 | 182 | 194 | 220 |
| 7.0 | 65 | 82 | 97 | 110 | 121 | 132 | 142 | 152 | 160 | 170 | 178 | 186 | 192 | 200 | 209 | 221 | 233 | 263 |
| 7.5 | 80 | 101 | 117 | 132 | 147 | 159 | 170 | 180 | 192 | 200 | 213 | 222 | 230 | 240 | 248 | 264 | 280 | 315 |
| 8.0 | 98 | 118 | 138 | 156 | 172 | 188 | 200 | 215 | 230 | 240 | 250 | 262 | 272 | 282 | 292 | 310 | 330 | 370 |
| 8.5 | 114 | 142 | 166 | 187 | 207 | 225 | 242 | 258 | 273 | 267 | 301 | 315 | 328 | 341 | 353 | 376 | 398 | 450 |
| 9.0 | 133 | 166 | 194 | 218 | 241 | 263 | 282 | 301 | 322 | 336 | 352 | 367 | 382 | 397 | 412 | 440 | 465 | 526 |
| 9.5 | 153 | 191 | 223 | 252 | 278 | 303 | 325 | 347 | 368 | 387 | 406 | 425 | 442 | 460 | 475 | 507 | 538 | 608 |
| 10.0 | 177 | 220 | 257 | 292 | 321 | 350 | 376 | 402 | 427 | 450 | 471 | 491 | 511 | 530 | 549 | 586 | 618 | 700 |
| 10.5 | 201 | 252 | 293 | 331 | 364 | 396 | 426 | 455 | 482 | 507 | 531 | 555 | 578 | 600 | 621 | 662 | 702 | 791 |
| 11.0 | 228 | 284 | 332 | 357 | 413 | 450 | 482 | 514 | 544 | 573 | 600 | 628 | 654 | 680 | 703 | 748 | 793 | 893 |
| 11.5 | 258 | 322 | 375 | 423 | 468 | 508 | 546 | 582 | 617 | 648 | 681 | 711 | 741 | 768 | 798 | 849 | 898 | 1015 |
| 12.0 | 291 | 361 | 422 | 475 | 525 | 572 | 612 | 652 | 692 | 729 | 765 | 798 | 830 | 862 | 892 | 950 | 1007 | 1135 |
| 12.5 | 321 | 400 | 467 | 527 | 581 | 632 | 678 | 724 | 767 | 807 | 846 | 883 | 919 | 954 | 988 | 1056 | 1118 | 1260 |
| 13.0 | 355 | 442 | 517 | 583 | 643 | 698 | 751 | 792 | 847 | 893 | 937 | 979 | 1020 | 1058 | 1096 | 1170 | 1232 | 1396 |
| 13.5 | 392 | 488 | 570 | 642 | 708 | 770 | 827 | 882 | 932 | 982 | 1030 | 1075 | 1122 | 1164 | 1205 | 1285 | 1360 | 1535 |
| 14.0 | 432 | 537 | 627 | 707 | 781 | 848 | 911 | 971 | 1026 | 1078 | 1130 | 1180 | 1230 | 1277 | 1322 | 1408 | 1497 | 1683 |
| 14.5 | 476 | 591 | 688 | 777 | 857 | 928 | 998 | 1063 | 1128 | 1185 | 1245 | 1300 | 1350 | 1400 | 1450 | 1545 | 1638 | 1643 |
| 15.0 | 521 | 648 | 766 | 852 | 938 | 1022 | 1092 | 1155 | 1285 | 1298 | 1359 | 1422 | 1476 | 1528 | 1587 | 1687 | 1788 | 2007 |
| 15.5 | 572 | 709 | 827 | 930 | 1025 | 1112 | 1190 | 1268 | 1343 | 1416 | 1485 | 1548 | 1610 | 1669 | 1726 | 1839 | 1943 | 2191 |
| 16.0 | 627 | 777 | 903 | 1015 | 1120 | 1215 | 1302 | 1385 | 1465 | 1540 | 1613 | 1683 | 1750 | 1815 | 1877 | 1997 | 2108 | 2375 |
| 16.5 | 681 | 842 | 978 | 1100 | 1213 | 1313 | 1408 | 1500 | 1585 | 1665 | 1745 | 1823 | 1893 | 1960 | 2023 | 2155 | 2277 | 2558 |
| 17.0 | 738 | 911 | 1012 | 1192 | 1312 | 1495 | 1527 | 1625 | 1722 | 1808 | 1892 | 1972 | 2050 | 2127 | 2200 | 2338 | 2465 | 2778 |
| 17.5 | 800 | 967 | 1144 | 1237 | 1415 | 1530 | 1543 | 1750 | 1850 | 1945 | 2035 | 2123 | 2208 | 2285 | 2365 | 2512 | 2660 | 2990 |
| 18.0 | 862 | 1065 | 1235 | 1385 | 1525 | 1650 | 1772 | 1885 | 1995 | 2100 | 2200 | 2295 | 2385 | 2470 | 2555 | 2720 | 2875 | 3230 |
| 18.5 | 922 | 1140 | 1325 | 1490 | 1640 | 1775 | 1900 | 2023 | 2140 | 2250 | 2355 | 2450 | 2550 | 2640 | 2735 | 2910 | 3035 | 3460 |
| 19.0 | 985 | 1223 | 1415 | 1590 | 1750 | 1890 | 2025 | 2160 | 2280 | 2400 | 2510 | 2618 | 2723 | 2815 | 2915 | 3105 | 3275 | 3680 |
| 19.5 | 1062 | 1308 | 1513 | 1705 | 1872 | 2025 | 2175 | 2310 | 2445 | 2570 | 2690 | 2860 | 2910 | 3015 | 3120 | 3320 | 3510 | 3920 |
| 20. | 1125 | 1390 | 1610 | 1810 | 1990 | 2155 | 2310 | 2460 | 2600 | 2735 | 2860 | 2985 | 3100 | 3210 | 3320 | 3535 | 3740 | 4200 |
| 20.5 | 1192 | 1475 | 1717 | 1925 | 2122 | 2300 | 2455 | 2650 | 2775 | 2915 | 3050 | 3190 | 3310 | 3430 | 3550 | 3780 | 4000 | 4500 |
| 21.0 | 1262 | 1565 | 1825 | 2055 | 2260 | 2455 | 2630 | 2800 | 2960 | 3115 | 2160 | 3400 | 3540 | 3670 | 3800 | 4040 | 4280 | 4815 |
| 21.5 | 1350 | 1673 | 1950 | 2192 | 2415 | 2615 | 2810 | 2990 | 3160 | 3325 | 3485 | 3635 | 3780 | 3820 | 4050 | 4320 | 4560 | 5130 |
| 22.0 | 1435 | 1780 | 2075 | 2330 | 2565 | 2780 | 2985 | 3180 | 3360 | 3535 | 3705 | 3870 | 4025 | 4165 | 4310 | 4580 | 4850 | 5450 |
| 22.5 | 1527 | 1890 | 2210 | 2485 | 2735 | 2960 | 3180 | 3380 | 3580 | 3765 | 3940 | 4115 | 4280 | 4440 | 4590 | 4885 | 5160 | 5815 |
| 23.0 | 1635 | 2023 | 2355 | 2645 | 2920 | 3155 | 3385 | 3610 | 3820 | 4010 | 4200 | 4390 | 4550 | 4720 | 4900 | 4210 | 4410 | 6190 |
| 23.5 | 1740 | 2160 | 2510 | 2830 | 3115 | 3375 | 3620 | 3855 | 4075 | 4290 | 4495 | 4680 | 4860 | 5035 | 5210 | 5540 | 5855 | 6585 |
| 24.0 | 1855 | 2300 | 2675 | 3000 | 3310 | 3575 | 3840 | 4085 | 4320 | 4535 | 4750 | 4950 | 5150 | 5335 | 5520 | 5885 | 6210 | 6980 |
| 24.5 | 1950 | 2415 | 2810 | 3160 | 3480 | 3775 | 4040 | 4300 | 4550 | 4780 | 5000 | 4220 | 5430 | 5650 | 5835 | 6200 | 6540 | 7330 |

750 1000 1500 2000

# C6 – RECTANGULAR DUCT EQUIVALENTS

| Actual round pipe diameter | Round pipe area sq. in. | Round circum-ference inches | Standard stack or riser size | Equivalent duct sizes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 4 depth | 5 depth | 6 depth | 7 depth | 8 depth | 9 depth | 10 depth | 12 depth | 14 depth |
| 4.0 | 12.5 | 12.56 | 10 x 3-1/4 | | | | | | | | | |
| 4.5 | 16 | 14.13 | 10 x 3-1/4 | | | | | | | | | |
| 5.0 | 20 | 15.70 | 10 x 3-1/4 | 5 x 4 | 4 x 5 | | | 3 x 8 | | | | |
| 5.5 | 24 | 17.30 | 10 x 3-1/4 | 7 x 4 | 5 x 5 | | | 4 x 8 | | | | |
| 6.0 | 28 | 18.84 | 12 x 3-1/4 | 8 x 4 | 6 x 5 | | | 4 x 8 | | | | |
| 6.5 | 33 | 20.41 | 12 x 3-1/4 | 9 x 4 | 7 x 5 | 6 x 6 | | 5 x 8 | | | | |
| 7.0 | 38 | 21.90 | 14 x 3-1/4 | 11 x 4 | 8 x 5 | 7 x 6 | | 5 x 8 | | | | |
| 7.5 | 44 | 23.55 | 14 x 3-1/4 | 13 x 4 | 10 x 5 | 8 x 6 | 7 x 7 | 6 x 8 | | | | |
| 8.0 | 50 | 25.13 | | 15 x 4 | 11 x 5 | 9 x 6 | 8 x 7 | 7 x 8 | | | | |
| 8.5 | 57 | 26.70 | | 17 x 4 | 13 x 5 | 10 x 6 | 9 x 7 | 8 x 8 | | | | |
| 9.0 | 64 | 28.27 | | 20 x 4 | 15 x 5 | 12 x 6 | 10 x 7 | 8 x 8 | | | | |
| 9.5 | 71 | 29.85 | | 22 x 4 | 17 x 5 | 13 x 6 | 11 x 7 | 9 x 8 | 8 x 9 | | | |
| 10.0 | 79 | 31.41 | | 25 x 4 | 19 x 5 | 15 x 6 | 12 x 7 | 11 x 8 | 9 x 9 | | | |
| 10.5 | 86 | 32.99 | | | 21 x 5 | 16 x 6 | 14 x 7 | 12 x 8 | 10 x 9 | 9 x 10 | | |
| 11.0 | 95 | 34.55 | | | 23 x 5 | 18 x 6 | 15 x 7 | 13 x 8 | 11 x 9 | 10 x 10 | | |
| 11.5 | 104 | 36.13 | | | 26 x 5 | 20 x 6 | 17 x 7 | 14 x 8 | 12 x 9 | 11 x 10 | | |
| 12.0 | 113 | 37.69 | | | 29 x 5 | 22 x 6 | 18 x 7 | 16 x 8 | 14 x 9 | 12 x 10 | | |
| 12.5 | 123 | 39.27 | | | 32 x 5 | 24 x 6 | 20 x 7 | 17 x 8 | 15 x 9 | 13 x 10 | 11 x 12 | |
| 13.0 | 133 | 40.84 | | | 35 x 5 | 27 x 6 | 22 x 7 | 18 x 8 | 16 x 9 | 14 x 10 | 12 x 12 | |
| 13.5 | 143 | 42.41 | | | | 30 x 6 | 24 x 7 | 20 x 8 | 17 x 9 | 16 x 10 | 13 x 12 | |
| 14.0 | 154 | 43.98 | | | | 32 x 6 | 26 x 7 | 22 x 8 | 19 x 9 | 17 x 10 | 14 x 12 | |
| 14.5 | 165 | 45.55 | | | | 35 x 6 | 28 x 7 | 24 x 8 | 20 x 9 | 18 x 10 | 15 x 12 | |
| 15.0 | 176 | 47.12 | | | | 38 x 6 | 31 x 7 | 26 x 8 | 22 x 9 | 19 x 10 | 16 x 12 | 14 x 14 |
| 15.5 | 189 | 48.69 | | | | 41 x 6 | 33 x 7 | 28 x 8 | 24 x 9 | 21 x 10 | 17 x 12 | 14 x 14 |
| 16.0 | 201 | 50.62 | | | | | 36 x 7 | 30 x 8 | 25 x 9 | 22 x 10 | 18 x 12 | 15 x 14 |
| 16.5 | 214 | 51.83 | | | | | 38 x 7 | 32 x 8 | 27 x 9 | 24 x 10 | 19 x 12 | 16 x 14 |
| 17.0 | 227 | 53.40 | | | | | 41 x 7 | 34 x 8 | 29 x 9 | 25 x 10 | 21 x 12 | 17 x 14 |
| 17.5 | 240 | 54.98 | | | | | 44 x 7 | 37 x 8 | 31 x 9 | 27 x 10 | 22 x 12 | 18 x 14 |
| 18.0 | 254 | 56.54 | | | | | | 39 x 8 | 33 x 9 | 29 x 10 | 23 x 12 | 20 x 14 |
| 18.5 | 269 | 58.12 | | | | | | 42 x 8 | 36 x 9 | 31 x 10 | 25 x 12 | 21 x 14 |
| 19.0 | 284 | 59.69 | | | | | | 45 x 8 | 38 x 9 | 33 x 10 | 26 x 12 | 22 x 14 |
| 19.5 | 299 | 61.26 | | | | | | 47 x 8 | 41 x 9 | 35 x 10 | 28 x 12 | 23 x 14 |
| 20.0 | 314 | 62.83 | | | | | | | 43 x 9 | 37 x 10 | 29 x 12 | 25 x 14 |
| 20.5 | 330 | 64.40 | | | | | | | 46 x 9 | 39 x 10 | 31 x 12 | 26 x 14 |
| 21.0 | 346 | 65.97 | | | | | | | 48 x 9 | 42 x 10 | 33 x 12 | 27 x 14 |
| 21.5 | 363 | 67.49 | | | | | | | 51 x 9 | 44 x 10 | 34 x 12 | 29 x 14 |
| 22.0 | 380 | 69.11 | | | | | | | | 47 x 10 | 36 x 12 | 30 x 14 |
| | | | | | | | | | | ** | | |

NOTE: 1) These equivalent sizes are for equal friction and capacity only - not for equal cross sectional area or velocity.

NOTE: 2) ** Ducts with an aspect ratio of more than 4 to 1 are not recommended.

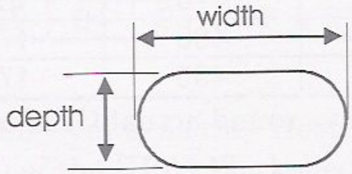
NOTE: 3) It is acceptable but not recommended that 10 x 3 1/4 duct be used for round pipe sizes between 5.5" and 6.0" diameter. 12 x 3 1/4 duct must be used for a round pipe size of 6.01" diameter.

# C7 - OVAL DUCT EQUIVALENTS

| Actual round pipe diameter | Round pipe area sq. in. | Round circum-ference inches | Standard stack or riser size | Equivalent duct sizes | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 3 depth | 4 depth | 5 depth | 6 depth | 7 depth |
| 4.0 | 12.5 | 12.56 | 6 x 2-3/4 | | | | | |
| 4.5 | 16 | 14.13 | 7-3/4 x 3 | | | | | |
| 5.0 | 20 | 15.70 | 7-3/4 x 3 | 8 x 3 | | | | |
| 5.5 | 24 | 17.30 | 9-1/4 x 3 | 9 x 3 | 7 x 4 | | | |
| 6.0 | 28 | 18.84 | | 11 x 3 | 8 x 4 | | | |
| 6.5 | 33 | 20.41 | | 12 x 3 | 10 x 4 | 8 x 5 | | |
| 7.0 | 38 | 21.90 | | 15 x 3 | 12 x 4 | | 8 x 6 | |
| 7.5 | 44 | 23.55 | | | 13 x 4 | 10 x 5 | 9 x 6 | |
| 8.0 | 50 | 25.13 | | | 15 x 4 | 11 x 5 | | |
| 8.5 | 57 | 26.70 | | | 17 x 4 | 13 x 5 | 11 x 6 | 10 x 7 |
| 9.0 | 64 | 28.27 | | | | 15 x 5 | 12 x 6 | |
| 9.5 | 71 | 29.85 | | | | 17 x 5 | 14 x 6 | 12 x 7 |
| 10.0 | 79 | 31.41 | | | | 19 x 5 | 15 x 6 | 13 x 7 |
| 10.5 | 86 | 32.99 | | | | | | 15 x 7 |
| 11.0 | 95 | 34.55 | | | | | 19 x 6 | |
| 11.5 | 104 | 36.13 | | | | | | 18 x 7 |
| 12.0 | 113 | 37.69 | | | | | 22 x 6 | |
| 12.5 | 123 | 39.27 | | | | | 25 x 6 | 21 x 7 |
| 13.0 | 133 | 40.84 | | | | | | |
| 13.5 | 143 | 42.41 | | | | | | |

NOTE: 1) These equivalent sizes are for equal friction and capacity only - not for equal cross sectional area or velocity.

NOTE: 2) The dimensions for oval pipe are given as follows:




NOTE: 3) When an oval pipe is referred to by a round equivalent by a manufacturer, it is usually equivalent circumference which is being referred to. For example, a 5" oval pipe has the same circumference as a 5" round pipe, but considerably less cross-sectional area and air handling ability.

# C8 – RECOMMENDED RETURN AIR INLET GRILLE FREE AREA

| RECOMMENDED FREE AREA IN SQ. IN. THROUGH RETURN AIR INLET GRILLES assuming face velocity of 400 ft/min | | | | | |
|---|---|---|---|---|---|
| Capacity CFM | Required free area sq. in. | Capacity CFM | Required free area sq. in. | Capacity CFM | Required free area sq. in. |
| 100 | 36 | 300 | 108 | 500 | 180 |
| 110 | 40 | 310 | 112 | 510 | 184 |
| 120 | 43 | 320 | 115 | 520 | 187 |
| 130 | 47 | 330 | 119 | 530 | 191 |
| 140 | 50 | 340 | 122 | 540 | 195 |
| 150 | 54 | 350 | 126 | 550 | 198 |
| 160 | 58 | 360 | 130 | 560 | 202 |
| 170 | 61 | 370 | 133 | 570 | 205 |
| 180 | 65 | 380 | 137 | 580 | 209 |
| 190 | 68 | 390 | 140 | 590 | 212 |
| 200 | 72 | 400 | 144 | 600 | 216 |
| 210 | 76 | 410 | 148 | 610 | 220 |
| 220 | 79 | 420 | 151 | 620 | 223 |
| 230 | 83 | 430 | 155 | 630 | 227 |
| 240 | 86 | 440 | 158 | 640 | 230 |
| 250 | 90 | 450 | 162 | 650 | 234 |
| 260 | 94 | 460 | 166 | 660 | 238 |
| 270 | 97 | 470 | 169 | 670 | 241 |
| 280 | 101 | 480 | 173 | 680 | 245 |
| 290 | 104 | 490 | 176 | 690 | 248 |

NOTE: 1) For chart CFM always round actual CFM up to nearest 10 CFM.

NOTE: 2) Free area is the combined area of the openings through which air flows.

NOTE: 3) Minimum free area requirements of return air intakes for any capacity can be determined by the following equation:

$$\text{Minimum free area} = \frac{\text{CFM} \times 144}{400}$$

Where : CFM = the required capacity in cubic feet per minute
144 = the number of square inches in 1 square foot
400 = the face velocity at the return air grill in feet per minute

This formula can be simplified to Minimum free area = CFM x 0.36

# C9 - MIXED AIR TEMPERATURE CHARTS

## C9a - PERCENT HOUSE AIR (%)

| Return Air Flow (CFM) | Outdoor Air (CFM) 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 500 | 92 | 88 | 84 | 80 | 76 | 72 | 68 | 64 | 60 | | | |
| 550 | 93 | 89 | 85 | 82 | 78 | 75 | 71 | 67 | 64 | 60 | | |
| 600 | 93 | 90 | 87 | 83 | 80 | 77 | 73 | 70 | 67 | 63 | 60 | |
| 650 | 94 | 91 | 88 | 85 | 82 | 78 | 75 | 72 | 69 | 66 | 63 | 60 |
| 700 | 94 | 91 | 89 | 86 | 83 | 80 | 77 | 74 | 71 | 69 | 66 | 63 |
| 750 | 95 | 92 | 89 | 87 | 84 | 81 | 79 | 76 | 73 | 71 | 68 | 65 |
| 800 | 95 | 93 | 90 | 88 | 85 | 83 | 80 | 78 | 75 | 73 | 70 | 68 |
| 850 | 95 | 93 | 91 | 88 | 86 | 84 | 81 | 79 | 76 | 74 | 72 | 69 |
| 900 | 96 | 93 | 91 | 89 | 87 | 84 | 82 | 80 | 78 | 76 | 73 | 71 |
| 950 | 96 | 94 | 92 | 89 | 87 | 85 | 83 | 81 | 79 | 77 | 75 | 73 |
| 1000 | 96 | 94 | 92 | 90 | 88 | 86 | 84 | 82 | 80 | 78 | 76 | 74 |
| 1100 | 96 | 95 | 93 | 91 | 89 | 87 | 85 | 84 | 82 | 80 | 78 | 76 |
| 1200 | 97 | 95 | 93 | 92 | 90 | 88 | 87 | 85 | 83 | 82 | 80 | 78 |
| 1300 | 97 | 95 | 94 | 92 | 91 | 89 | 87 | 86 | 84 | 83 | 82 | 80 |
| 1400 | 97 | 96 | 94 | 93 | 91 | 90 | 89 | 87 | 86 | 84 | 83 | 81 |
| 1500 | 97 | 96 | 95 | 93 | 92 | 91 | 89 | 88 | 87 | 85 | 84 | 83 |
| 1600 | 98 | 96 | 95 | 94 | 93 | 91 | 90 | 89 | 88 | 86 | 85 | 84 |
| 1700 | 98 | 96 | 95 | 94 | 93 | 92 | 90 | 89 | 88 | 86 | 85 | 84 |
| 1800 | 98 | 97 | 96 | 94 | 93 | 92 | 91 | 90 | 89 | 88 | 87 | 86 |
| 1900 | 98 | 97 | 96 | 95 | 94 | 93 | 92 | 91 | 89 | 88 | 87 | 86 |
| 2000 | 98 | 97 | 96 | 95 | 94 | 93 | 92 | 91 | 90 | 89 | 88 | 87 |

NOTE: 1) Return air flow (cfm)is the same value as the "Heating Air Flow Rate (cfm)" found on page 2, Part B (B.4) of the HRAI Worksheet for Residential Air System Design.

NOTE: 2) The percent of house air can also be found by using the formula:

$$\text{Percent house air} = \frac{(\text{Return Air Flow} - \text{Outdoor Air})}{\text{Return Air Flow}}$$

# C9b - HRV AIR DELIVERY TEMPERATURE (°F)

| Outdoor Design Temp.(°F) | HRV Effectiveness at Winter Outdoor Design Temperature | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 95% | 90% | 85% | 80% | 75% | 70% | 65% | 60% | 55% |
| 10 | 65 | 62 | 59 | 56 | 54 | 51 | 48 | 45 | 42 |
| 8 | 65 | 62 | 59 | 56 | 53 | 50 | 47 | 44 | 41 |
| 6 | 65 | 62 | 59 | 56 | 53 | 49 | 46 | 43 | 40 |
| 4 | 65 | 62 | 58 | 55 | 52 | 49 | 46 | 42 | 39 |
| 2 | 65 | 61 | 58 | 55 | 52 | 48 | 45 | 42 | 38 |
| 0 | 65 | 61 | 58 | 54 | 51 | 48 | 44 | 41 | 37 |
| -2 | 65 | 61 | 58 | 54 | 51 | 47 | 44 | 40 | 37 |
| -4 | 64 | 61 | 57 | 54 | 50 | 46 | 43 | 39 | 36 |
| -6 | 64 | 61 | 57 | 53 | 50 | 46 | 42 | 38 | 35 |
| -8 | 64 | 60 | 57 | 53 | 49 | 45 | 41 | 38 | 34 |
| -10 | 64 | 60 | 56 | 52 | 49 | 45 | 41 | 37 | 33 |
| -12 | 64 | 60 | 56 | 52 | 48 | 44 | 40 | 36 | 32 |
| -14 | 64 | 60 | 56 | 52 | 48 | 43 | 39 | 35 | 31 |
| -16 | 64 | 60 | 55 | 51 | 47 | 43 | 39 | 34 | 30 |
| -18 | 64 | 59 | 55 | 51 | 47 | 42 | 38 | 34 | 29 |
| -20 | 64 | 59 | 55 | 50 | 46 | 42 | 37 | 33 | 28 |
| -22 | 64 | 59 | 55 | 50 | 46 | 41 | 37 | 32 | 27 |
| -24 | 63 | 59 | 54 | 50 | 45 | 40 | 36 | 31 | 27 |
| -26 | 63 | 59 | 54 | 49 | 45 | 40 | 35 | 30 | 26 |
| -28 | 63 | 58 | 54 | 49 | 44 | 39 | 34 | 30 | 25 |
| -30 | 63 | 58 | 53 | 48 | 44 | 39 | 34 | 29 | 24 |
| -32 | 63 | 58 | 53 | 48 | 43 | 38 | 33 | 28 | 23 |
| -34 | 63 | 58 | 53 | 48 | 43 | 37 | 32 | 27 | 22 |
| -36 | 63 | 58 | 52 | 47 | 42 | 37 | 32 | 26 | 21 |
| -38 | 63 | 57 | 52 | 47 | 42 | 36 | 31 | 25 | 20 |
| -40 | 63 | 57 | 52 | 46 | 41 | 36 | 30 | 25 | 19 |

NOTE: 1) The HRV delivery temperature can also be found by using the formula:

$$DT = ODT + \left[ (RAT - ODT) \times \frac{\%HRV\ eff.}{100} \right]$$

Where: DT = HRV delivery temperature
ODT = January 2 1/2% outdoor design temperature
RAT = return air temperature (68 °F)
%HRV eff. = percent HRV sensible effectiveness

# C9c - MIXED AIR TEMPERATURE (°F)

| ODT or DT (°F) | Percent House Air 95% | 90% | 85% | 80% | 75% | 70% | 65% | 60% |
|---|---|---|---|---|---|---|---|---|
| 52 | 67 | 66 | 66 | 65 | 64 | 63 | 62 | 62 |
| 48 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 |
| 44 | 67 | 66 | 64 | 63 | 62 | 61 | 60 | 58 |
| 40 | 67 | 65 | 64 | 62 | 61 | 60 | 58 | 57 |
| 36 | 66 | 65 | 63 | 62 | 60 | 58 | 57 | 55 |
| 32 | 66 | 64 | 63 | 61 | 59 | 57 | 55 | 54 |
| 28 | 66 | 64 | 62 | 60 | 58 | 56 | 54 | 52 |
| 24 | 66 | 64 | 61 | 59 | 57 | 55 | 53 | 50 |
| 20 | 66 | 63 | 61 | 58 | 56 | 54 | 51 | 49 |
| 18 | 66 | 63 | 61 | 58 | 56 | 53 | 51 | 48 |
| 14 | 65 | 63 | 60 | 57 | 55 | 52 | 49 | 46 |
| 10 | 65 | 62 | 59 | 56 | 54 | 51 | 48 | 45 |
| 8 | 65 | 62 | 59 | 56 | 53 | 50 | 47 | 44 |
| 6 | 65 | 62 | 59 | 56 | 53 | 49 | 46 | 43 |
| 4 | 65 | 62 | 58 | 55 | 52 | 49 | 46 | 42 |
| 2 | 65 | 61 | 58 | 55 | 52 | 48 | 45 | 42 |
| 0 | 65 | 61 | 58 | 54 | 51 | 48 | 44 | 41 |
| -2 | 65 | 61 | 58 | 54 | 51 | 47 | 44 | 40 |
| -4 | 64 | 61 | 57 | 54 | 50 | 46 | 43 | 39 |
| -6 | 64 | 61 | 57 | 53 | 50 | 46 | 42 | 38 |
| -8 | 64 | 60 | 57 | 53 | 49 | 45 | 41 | 38 |
| -10 | 64 | 60 | 56 | 52 | 49 | 45 | 41 | 37 |
| -12 | 64 | 60 | 56 | 52 | 48 | 44 | 40 | 36 |
| -14 | 64 | 60 | 56 | 52 | 48 | 43 | 39 | 35 |
| -16 | 64 | 60 | 55 | 51 | 47 | 43 | 39 | 34 |
| -18 | 64 | 59 | 55 | 51 | 47 | 42 | 38 | 34 |
| -20 | 64 | 59 | 55 | 50 | 46 | 42 | 37 | 33 |
| -22 | 64 | 59 | 55 | 50 | 46 | 41 | 37 | 32 |
| -24 | 63 | 59 | 55 | 50 | 45 | 40 | 36 | 31 |
| -26 | 63 | 59 | 54 | 49 | 45 | 40 | 35 | 30 |
| -28 | 63 | 58 | 54 | 49 | 44 | 39 | 34 | 30 |
| -30 | 63 | 58 | 53 | 48 | 44 | 39 | 34 | 29 |
| -32 | 63 | 58 | 53 | 48 | 43 | 38 | 33 | 28 |
| -34 | 63 | 58 | 53 | 48 | 43 | 37 | 32 | 27 |
| -36 | 63 | 58 | 52 | 47 | 42 | 37 | 32 | 26 |
| -40 | 63 | 57 | 52 | 46 | 41 | 36 | 30 | 25 |

NOTE: 1) The mixed air temperature can also be found by using the formula:

$$MAT = RAT - \left[(RAT - DT) \times \frac{100 - \%HA}{100}\right]$$

Where:
- MAT = mixed air temperature
- ODT = Jan. 2 1/2% outdoor design temperature
- RAT = return air temperature (68 °F)
- DT = HRV air delivery temperature from C9b (where there is no heat recovery use Jan. 2 1/2% outdoor design temperature)
- % HA = percentage house air from C9a

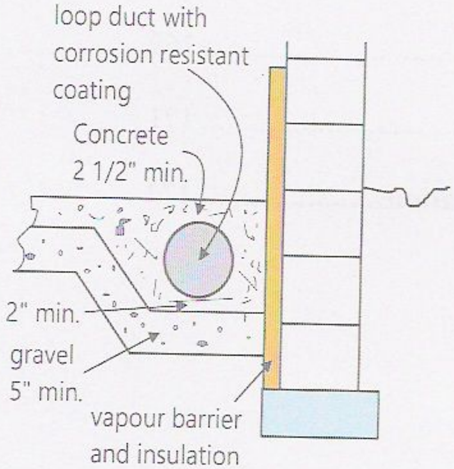
# APPENDIX D

# IN-SLAB SYSTEMS

# D 1 In-Slab Systems

### *D 1.1 General*

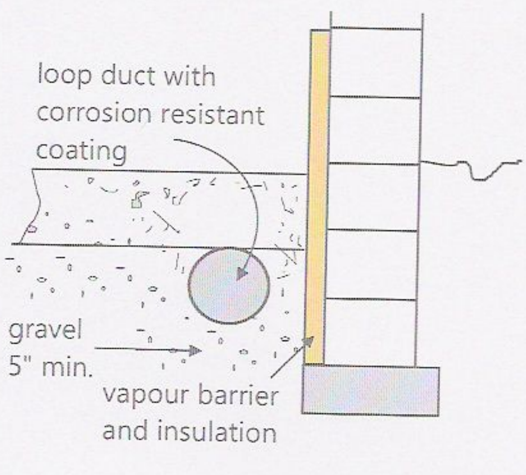
Installing ducts in concrete slab is a special technique with materials changing and constantly improving. Consider this appendix as a guideline of what constitutes good practice. It is strongly recommended that the contractor communicate with the authority having jurisdiction (usually the building official) prior to design to confirm requirements under local code interpretations.



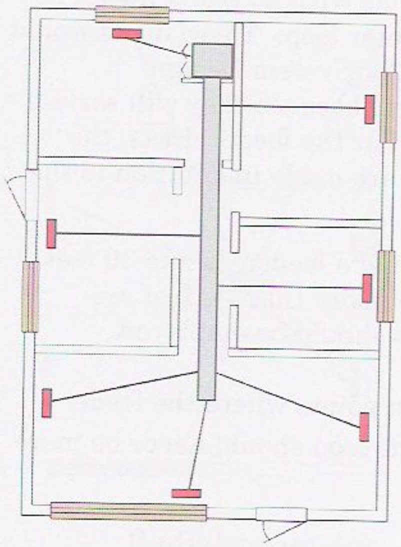

There are two types of "in-slab" systems. They are the "perimeter loop" and "radial perimeter" type.

For both types of systems the following conditions apply:

- All ducts in or beneath a concrete slab-on-ground shall be water tight and corrosion, decay, and mildew resistant.
- All ducts shall have a minimum of 2 1/2 inches of concrete above the duct.
- Aluminum must not be used as a duct material.
- Underground ducts shall be sloped to provide interior drainage and shall not be connected directly to a sewer.
- All duct materials should be equivalent in strength and durability to 26 gauge galvanized steel, round duct of 8 inch diameter (spiral preferred).
- Duct joints shall be sufficiently tight to prevent entrance of fluid concrete. The joint must be strong enough so that the duct system is rigid and ducts cannot be dislodged during the pouring of the slab. The use of tie-downs is recommended to prevent movement of ducts.
- Avoid running the duct where it will interfere with utility pipes, etc.



- Wherever ducts pierce a vapour barrier, the vapour barrier must be sealed air tight.
- Stepping on light weight ducts may crush them. A damaged duct must be replaced before the slab is poured.
- The under-slab fill should be of a coarse uniform size material (minimum 5 inches deep). The use of gravel or crushed rock that has been pushed over a coarse screen is desirable. Cinders shall not be used.



Perimeter loop system
with trunk duct

### *D1.2 Perimeter Loop Systems*

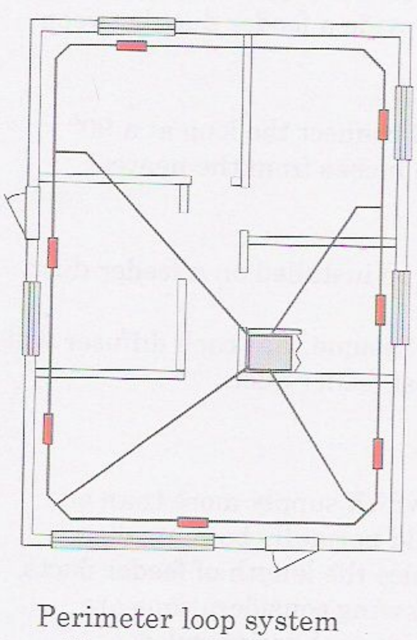
A perimeter loop in-slab duct system has three main parts:

- the perimeter loop
- the feeder ducts
- the trunk ducts

#### Perimeter Loop

The perimeter loop consists of a duct (usually round) which runs along the exposed perimeter of the space to be conditioned and is used to feed diffusers which are spaced at intervals along the loop. The positioning and sizing of these diffusers is the same as traditional type residential duct systems. In other words the diffusers are positioned and sized according to the heat loss/gain and exposure in the individual room(s). For the perimeter loop, the following considerations are required to be made in addition to the normal design rules:

- A loop perimeter system is limited to supplying a maximum of 100,000 Btu/h. An area of a building using an "in-slab" system, and having a Total Heat Loss greater than 100,000 Btu/h should be heated using two separate systems, each having a separate heating source.
- A loop perimeter system is limited to servicing an area having a maximum exposed perimeter of 210 feet.



Perimeter loop system
without trunk duct
(preferred method)

- The loop shall be of the same size (diameter) as the size of the largest feeder duct servicing the loop.

**Feeder Ducts**

Feeder ducts are the ducts which carry air from the furnace plenum (in systems with no trunk ducts) or trunk ducts to the perimeter loop. These ducts would be entered on the HRAI Air System Design Worksheets as trunk ducts because they will service more than one diffuser. For the feeder ducts, the following considerations are made in addition to the normal design rules:

- The maximum length of a feeder duct is 30 feet. Where feeder ducts of more than 30 feet are required, trunk ducts should be employed.
- The distance between points where the feeder ducts connect with the loop should never be more than 35 feet.
- There should never be more than 3 diffusers in a section of the loop between two feeder ducts.
- If the distance between two adjacent diffusers is more than 20 feet, provide a feeder duct between such diffusers.
- All feeder ducts must connect the loop at a 90° angle and at least 18 inches from the nearest diffuser.
- Diffusers should not be installed on a feeder duct.
- For sizing purposes, assume that each diffuser will be fed from the closest feeder duct.

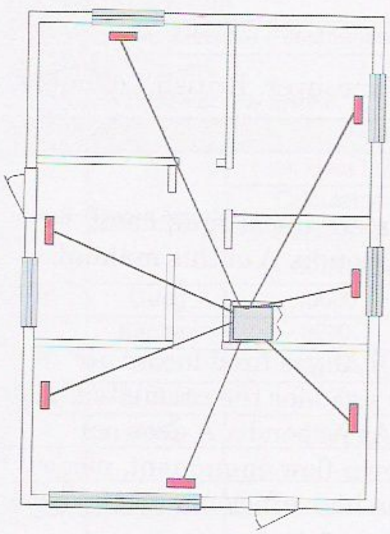
**Trunk Ducts**

Trunk ducts are ducts which supply more than one feeder duct. These would normally be centrally located and used to reduce the length of feeder ducts. For trunk ducts the following considerations are made in addition to the normal design rules:

- Trunk duct should have a maximum length of 50 feet.

- Trunk ducts should be insulated with a minimum of 2 inch rigid or semi rigid insulation ( R6).

- Trunk duct sizing will be based on the same criteria as a trunk duct in any type of Residential duct system. Round Trunks are preferred.



Radial perimeter system

### *D 1.3 Radial Perimeter Systems*

Radial perimeter "in-slab" systems will have a series of branch ducts from a plenum or main trunk. These branch ducts will service one diffuser each. The diffusers will be positioned and sized according to the heat loss/gain and exposure in the individual room(s) as in any other type of perimeter heating/cooling system.

Trunk and branch duct sizing will be completed using the HRAI Residential Air System Design Worksheets in the same manner as for any other residential duct system.

# D 2 Perimeter Loop Example

***Customer:***

Mr. Slab, 50 Gateway Ave.,

Vancouver, British Columbia, K1M 4G1

Phone (604) 222-3333 Fax (604) 222-3334

***Location:***

The house is to be built in Vancouver, British Columbia. House volume is 4160 cu. ft.

***Design Conditions:***

**Note:** Specification for the mechanical equipment required, can be found in Appendix A of this manual.

***Heating:***

The heating unit will be a DLM gas fired forced air down flow furnace properly sized for the calculated heat loss including ventilation. As Appendix A does not include specifications for down-flow equipment, please use the specifications for the high efficiency gas furnace.

***Cooling:***

The cooling unit will not be installed at this time. Allow for a coil pressure drop of 0.2 in. W.C. Customer has requested cooling capability even though cooling is not required because the ODT below 82 °F

***Air Filter:***

The standard 1" fiberglass filter which comes with the furnace will be used.

***Duct System:***

The duct system shall conform to the duct layout drawings and floor plans on the following pages.

***Ventilation:***

Required as this is a new home, but this is not an integrated system and therefore a mixed air temperature calculation is also **not** required

**Note:** Designer uses 60% heating capacity for sizing purposes and estimates cooling unit capacity at 1-1/2 tons. Duct design pressure is estimated at 0.20 in W.C. Home owner selects 4" x 10" steel floor registers.

**HRAI Residential Heat Loss and Heat Gain Calculations** — Page 2

**SECTION B — DESIGN CONDITIONS**

| HEAT LOSS | | | HEAT GAIN | | |
|---|---|---|---|---|---|
| Outdoor Design Temperature Heating(ODT) | 19 | °F / ~~°C~~ | Outdoor Design Temperature Cooling (ODT) | 79 | °F / ~~°C~~ |
| Indoor Design Temperature (IDT) | 72 | °F / ~~°C~~ | Indoor Design Temperature (IDT) | 75 | °F / ~~°C~~ |
| Mean Soil Temperature | 52 | °F / ~~°C~~ | North Latitude | 49 | ° |
| | | | Summer Mean Daily Temperature Range | 22 | °F / ~~°C~~ |
| Building Volume (Vb) | 4160 | $ft^3$ / ~~$m^3$~~ | Building Conditioned Area | 520 | $ft^2$ / ~~$m^2$~~ |

HRV Apparent Sensible Effectiveness = N/A (insert N/A if no HRV/ERV installed)

Ventilation System:

☐ Case #1: Exhaust Only System ☐ Case #2: Direct Ducted System ☑ Case #3: Central Forced Air Syst

**SECTION C — ROOM HEAT LOSS / HEAT GAIN SUMMARY**

| Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ | Level | Room Name | Total Heat Loss Calculated Section 16 Btuh/~~W~~ | Total Heat Gain Calculated Section 17 Btuh/~~W~~ |
|---|---|---|---|---|---|---|---|
| 1 | Living | 10600 | 7100 | | | | |
| 1 | Kitchen | 3200 | 2000 | | | | |
| 1 | Bath | 1400 | 700 | | | | |
| 1 | M Bed | 4200 | 2560 | | | | |
| 1 | Utility | 1900 | 629 | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | **SUB TOTAL** | | 21300 Section 18 | 12989 Section 21 |

**SECTION D — BUILDING HEAT LOSS SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Loss | (Section 18) | 21300 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Loss | (Section 19) | N/A | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Loss** | (Section 20) | 22531 | Btuh/~~W~~ | |

**SECTION E — BUILDING HEAT GAIN SUMMARY**

| | | | | |
|---|---|---|---|---|
| Building Sub Total Heat Gain | (Section 21) | 12989 | Btuh/~~W~~ | |
| Central Forced Air Ventilation Heat Gain | (Section 22) | n/a | Btuh/~~W~~ | *Only applicable for ventilation case #3 |
| **Total Building Heat Gain** | (Section 23) | 13248 | Btuh/~~W~~ | |

**Notes:**

In this example, Ventilation would have been included in the Sub Total Heat Loss; therefore each room must be increased (multiplied by) 1.0578. Similarly with the Sub Total Heat Gain and each room must be increased by

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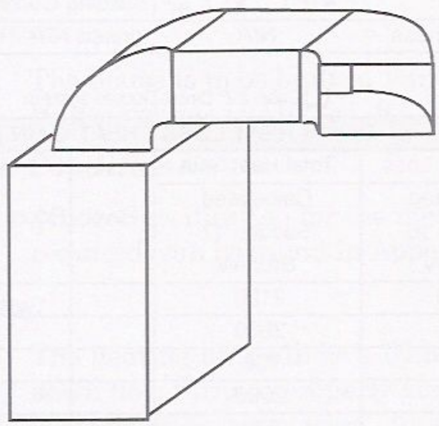
Mississauga, Ontario L4W 5G9

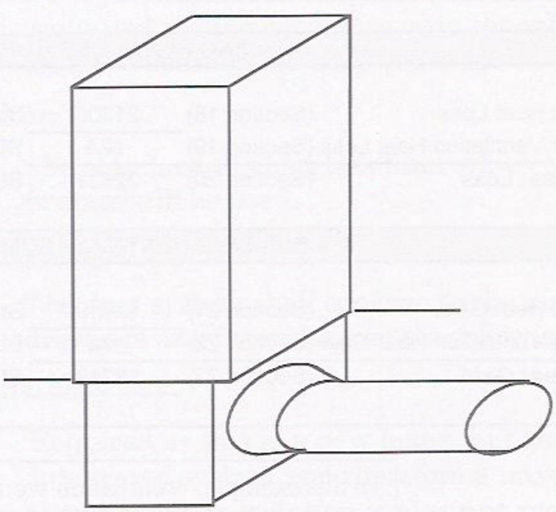
ver. Jul / 2017

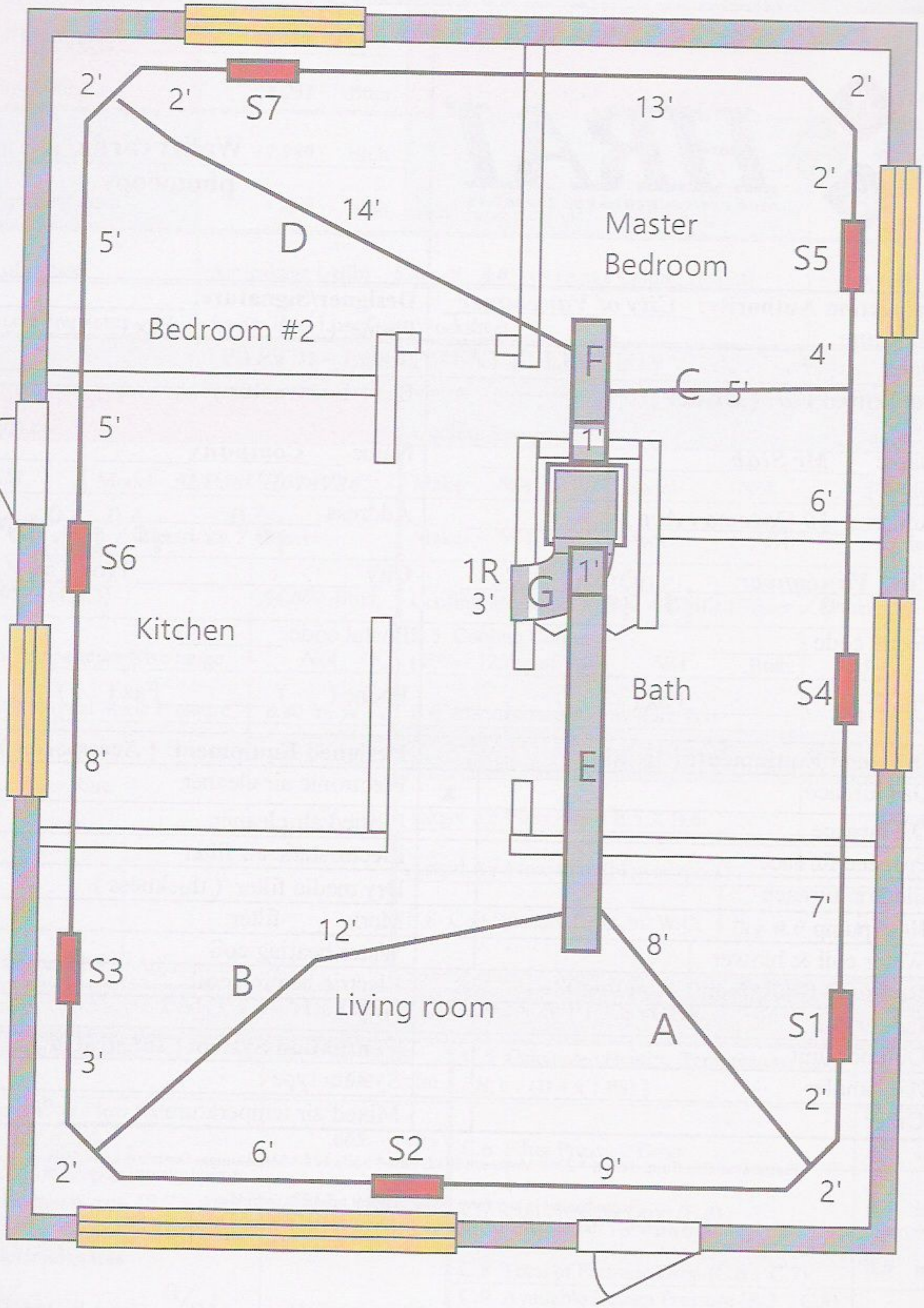
**Note:** The following two drawings demonstrate the general configuration of the ductwork near the furnace. Although not to scale nor complete in detail, their purpose is to provide a clear indication of the fittings used and the path the air must follow as it enters and leaves the furnace.

***Return Air***



***Supply Air***




2'
2'
S7
13'
2'
2'
14'
D
5'
Master
Bedroom
S5
Bedroom #2
F
4'
C
5'
5'
1'
6'
S6
1R
3'
G
1'
Kitchen
Bath
S4
8'
E
7'
12'
8'
S3
B
Living room
A
S1
3'
2'
S2
6'
2'
9'
2'

## WORKSHEET FOR RESIDENTIAL AIR SYSTEM DESIGN page 1

HRAI
YOUR ENVIRONMENT OUR EXPERTISE

**Wallet card photocopy**

| | |
|---|---|
| **Inspection Authority:** *City of Vancouver*<br>Signature: ____<br>Date: / / | **Designer/Signature:** ____<br>Phone: ( ) ____ Fax ( ) ____<br>Date: / / |
| **Submitted For: ( Owner )**<br>Name *Mr Slab*<br>Address *50 Gateway Ave*<br>City *Vancouver* Prov *B.C.*<br>Postal code ____<br>Phone ( ) ____ Fax ( ) ____ | **By: ( Contractor )**<br>Name *Company*<br>Address ____<br>City ____ Prov ____<br>Postal code ____<br>Phone ( ) ____ Fax ( ) ____ |

| **Designed Equipment: ( Heating )** | | **Designed Equipment: ( Accessories )** | |
|---|---|---|---|
| Gas furnace | *x* | Electronic air cleaner | |
| Oil furnace | | Pleated air cleaner | |
| Propane furnace | | Electrostatic air filter | |
| Electric furnace | | Dry media filter ( thickness ) " | |
| Heat pump | | Merv ____ filter | |
| Water coil & blower | | Water heating coil | |
| **Designed Equipment: (Cooling )** | | Electric heating coil | |
| Indoor coil | | Other | |
| Outdoor unit | | **Ventilation System ( Integrated )** | |
| Air handler | | System type : | |
| Other | | Mixed air temperature ____ °F | |

Forms available from: HRAI * 2350 Matheson Blvd. East * Suite 101 * Mississauga, Ontario * L4W 5G9

## PART A - DESIGN LOAD SPECIFICATIONS

page 2

| | | | |
|---|---|---|---|
| A.1 Sub Total Heat Loss | *21,300* Btuh. | | |
| A.2 Ventilation Heat Loss | *1,231* Btuh. | A.3 Total Heat Loss (A.1 + A.2) | *22,521* Btuh. |
| A.4 Sub Total Heat Gain | *12,989* Btuh. | | |
| A.5 Ventilation Heat Gain | *259* Btuh. | A.6 Total Heat Gain (A.4 + A.5) | *13,248* Btuh. |
| A.7 Volume of House: | Air leakage (Aflb) 520 X *8.0'* (Average Ceiling Height) | | *4,160* cu ft. |
| A.8 Ventilation Flow Rate: | As per Heat Loss/Gain Worksheet | | *N/A* cfm. |

## PART B – EQUIPMENT SELECTION

| Heating Equipment: | |
|---|---|
| Make *DLM* | Model *SLP98UH070V36* |
| Fuel Type: ☒ Gas ☐ Oil ☐ Electricity ☐ Other | |
| B.1 Heating Output (Minimum 100% - of A.3) | *64,000* Btuh. |
| B.2 Approved Temperature Rise/range | *N/A* °F. |
| B.3 Equipment External Static Pressure | *0.80* in. W.C. |
| B.4 Heating Air Flow Rate (blower specs) | *624* cfm |
| Speed setting: *Default/60%* | Adjustment: *N/A* |

| Cooling Equipment: | | |
|---|---|---|
| Make *N/A* | Model *N/A* | (Outdoor Unit) |
| Make *N/A* | Model *N/A* | (Indoor Unit) |
| Cooling Medium: ☐ DX ☐ Chilled Water ☐ Other | | |
| B.5 Cooling Output (80% - 125% of A.6) *N/A* Btuh | *1.5* Tons | |
| B.6 Manufacturers Flow Rate/Ton | *400* (cfm/ton) | |
| B.7 Cooling Air Flow Rate. | | |
| Target Air Flow rate = B.5 X B.6 | *600* cfm | |
| Actual Air Flow Rate (blower specs) | *665* cfm | |
| B.8 Coil Pressure Drop, in. W.C. | Dry *0.0* | Wet *0.2* |
| Speed Setting: Med/Low | Adjustment: *N/A* | |

## PART C – AIR DISTRIBUTION & PRESSURE

| | | | |
|---|---|---|---|
| C.1 Circulation Air Flow Rate ( A.7 x 0.025 ) | *104* cfm | C.5 Calculated Heating Temperature Rise [ B.1 ÷ (B.4 x 1.08) ] | *57.0* °F |
| C.2 System Design Air Flow Rate (highest of B.4, B.7, C.1) | *665* cfm | C.6 Filter Pressure Drop | *0.0* in. W.C. |
| C.3 Cooling Airflow Proportioning Factor Calculate to 4 decimal places (B.7 ÷ A.4) | *.0512* cfm/Btuh | C.7 Coil Pressure Drop (B.8) | *0.2* in. W.C. |
| C.4 Heating Airflow Proportioning Factor Calculate to 4 decimal places (C.2 ÷ A.1) ☒ or (B.4 ÷ A.1) ☐ | *.0312* cfm/Btuh | C.8 Total of Pressure Drop (C.6 + C.7) | *0.0* in. W.C. |
| | | C.9 Available Design Pressure (B.3 C.8) or Selected Design Pressure | *0.2* in. W.C. |

**Note:** When furnace standard filter is replaced, subtract its pressure drop from the replacement filter and record on line C.6

## PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES page 3

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| D.1 Floor | **1st Floor** | | | | | | | |
| D.2 Room | ***Liv*** | ***Kit*** | ***Bath*** | ***M/Bed*** | ***Bed 2*** | | | |
| D.3 Cooling load (Btuh) | *N/A* | ____ | ____ | ____ | ____ | | | |
| D.4 Room cooling flow rate (D.3 x C.3) | *N/A* | ____ | ____ | ____ | ____ | | | |
| D.5 Heating load (Btuh) | *10,600* | *3,200* | *1,400* | *4,200* | *1,900* | | | |
| D.6 Room heating flow rate (D.5 x C.4) | *331* | *100* | *44* | *131* | *59* | | | |
| D.7 Number of outlets per room | *3* | *1* | *1* | *1* | *1* | | | |
| D.8 Floor supply air flow rates (greatest airflow heating or cooling) | *665* | | | | | | | |

## PART D - CONTINUED

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| D.1 | | | | | | | | | | |
| D.2 | | | | | | | | | | |
| D.3 | | | | | | | | | | |
| D.4 | | | | | | | | | | |
| D.5 | | | | | | | | | | |
| D.6 | | | | | | | | | | |
| D.7 | | | | | | | | | | |
| D.8 | | | | | | | | | | |

## PART E - INLET FLOW RATES

| Floor level (Location) | Basement (50% D.8 Max) | 1st floor (Sum of D.8 Min) | 2nd floor (Sum of D.8 Min) | 3rd floor (Sum of D.8 Min) | Total = ( C.2 ) (System cfm) |
|---|---|---|---|---|---|
| E.1 Floor return air flow rate | *N/A* | *665* | *N/A* | *N/A* | *665* |
| E.2 Minimum number of openings | / | *1* | / | / | |
| E.3 Actual number of openings | / | *1* | / | / | |
| E.4 Actual cfm per opening ( E.1 ÷ E.3 ) | / | *665* | / | / | |

**Note:** After location of supply outlets and return inlets are determined, produce preliminary drawing.

| PART D - DETERMINING ROOM AND FLOOR DESIGN FLOW RATES | | | | | | | | page 3 |
|---|---|---|---|---|---|---|---|---|
| D.1 Floor | 1st Floor | | | | | | | |
| D.2 Room | *Liv* | *Kit* | *Bath* | *M/Bed* | *Bed 2* | | | |
| D.3 Cooling load (Btuh) | *N/A* | ____ | ____ | ____ | ____ | | | |
| D.4 Room cooling flow rate (D.3 x C.3) | *N/A* | ____ | ____ | ____ | ____ | | | |
| D.5 Heating load (Btuh) | *10,600* | *3,200* | *1,400* | *4,200* | *1,900* | | | |
| D.6 Room heating flow rate (D.5 x C.4) | *331* | *100* | *44* | *131* | *59* | | | |
| D.7 Number of outlets per room | *3* | *1* | *1* | *1* | *1* | | | |
| D.8 Floor supply air flow rates (greatest airflow heating or cooling) | *665* | | | | | | | |

| PART D - CONTINUED | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| D.1 | | | | | | | | | | |
| D.2 | | | | | | | | | | |
| D.3 | | | | | | | | | | |
| D.4 | | | | | | | | | | |
| D.5 | | | | | | | | | | |
| D.6 | | | | | | | | | | |
| D.7 | | | | | | | | | | |
| D.8 | | | | | | | | | | |

**PART E - INLET FLOW RATES**

| Floor level (Location) | Basement (50% D.8 Max) | 1st floor (Sum of D.8 Min) | 2nd floor (Sum of D.8 Min) | 3rd floor (Sum of D.8 Min) | Total = ( C.2 ) (System cfm) |
|---|---|---|---|---|---|
| E.1 Floor return air flow rate | *N/A* | *665* | *N/A* | *N/A* | *665* |
| E.2 Minimum number of openings | / | *1* | / | / | |
| E.3 Actual number of openings | / | *1* | / | / | |
| E.4 Actual cfm per opening ( E.1 ÷ E.3 ) | / | *665* | / | / | |

**Note:** After location of supply outlets and return inlets are determined, produce preliminary drawing.

## PART F - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR RETURN DUCTS

page 4

| Inlet No | Equipment Connection (Group 1) | Trunk To Drop Connection (Group 1) | Trunk Transitions (Group 2) | Trunk Fittings (Group 2) | Duct To Joist (Group 3) | Turbulence Effect | Stud To Joist (Group 4) | Grille Opening To Stud (Group 4) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| *R1* | *C-10* | / | / | *B-25* | / | / | / | / | *3* | *38* |
| | | | | | | | | | | |
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## PART G - DUCT DESIGN PRESSURE

G.1

(Return Branch Longest Effective Length __*38*__ ft).

G.2

**R/A Plenum Pressure:**

Available Design Pressure (Line C.9) x Return Air Apportioning Factor (Appendix C (C3))

( *0.20* ) x ( *0.25* ) = __*0.06*__ in. W.C. (Record Line H.8)

G.3

**S/A Plenum Pressure:**

Available Design pressure (Line C.9) - R/A Plenum Pressure

( *0.20* ) - ( *0.06* ) = __*0.14*__ in. W.C. (Record Line J.7)

## PART H - SIZING OF RETURN GRILLES, BRANCHES AND MAIN TRUNK DUCTS page 5

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H.1 Trunk Letter/No | *G* | | | | | | | | | |
| H.2 Inlet Location (Room) | *Hall* | | | | | | | | | |
| H.3 Inlet No (R) | *R1* | | | | | | | | | |
| H.4 Inlet flow rate (cfm) (Line E.4 adjusted) | *665* | | | | | | | | | |
| H.5 Minimum required inlet free area (sq. in.) (Appendix C8) | *241* | | | | | | | | | |
| H.6 Inlet size (Appendix A) | *30 x 10* | | | | | | | | | |
| H.7 Inlet Pressure Loss (in. W.C.) | *.02* | | | | | | | | | |
| H.8 R/A Plenum pressure (in. W.C.) (Line G.2) | *.06* | | | | | | | | | |
| H.9 Adjusted duct design pressure (H.8 - H.7) | *.04* | | | | | | | | | |
| H.10 Branch effective length (ft) (Part F) | *38* | | | | | | | | | |
| H.11 Loss/100 ft. of effective length [(H.9 x 100) ÷ H.10] | *0.11* | | | | | | | | | |
| H.12 Branch duct size (round) (H.4, H.11) (Appendix C4,5) | *12.0* | | | | | | | | | |
| H.13 Branch rectangular equivalent (Appendix C6) | *16 x 8* | | | | | | | | | |
| H.14 Joist to trunk opening size (2 x area H.13) | */* | | | | | | | | | |
| H.15 Trunk flow rate (cfm) accumulation of H.4 | *665* | | | | | | | | | |
| H.16 Lowest loss/100 ft encountered from duct end. | *0.11* | | | | | | | | | |
| H.17 Trunk duct size (round) (H.15, H.16) (Append C4,5) | *12.0* | | | | | | | | | |
| H.18 Trunk rectangular equivalent (Appendix C6) | *16 x 8* | | | | | | | | | |
| H.19 Installed Trunk size (Transitions) | *20 x 8* | | | | | | | | | |
| H.20 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | *599* | | | | | | | | | |

***Note: Designer increased trunk size to reduce velocity.***

## PART I - SUMMARY OF TOTAL EFFECTIVE LENGTHS FOR SUPPLY DUCTS page 6

| Outlet No | Plenum Fitting (Group 5) | Trunk Transition (Group 6) | Trunk Fittings (Group 6) | Trunk To Branch Take offs (Group 7) | Aspiration Effect | Duct Flex Length (ft) | Branch Elbows (Group 8) | Boot Fitting (Group 8) | Measured Length (ft) | Branch Effective Length (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| *S1* | *E-35* | / | *J-50* | *I-35+H-35* | *0* | / | *E-5* | / | *21* | *181* |
| *S2* | *E-35* | / | *J-50* | *I-35+H-35* | *0* | / | *E-5 x 2* | / | *28* | *193* |
| *S3* | *E-35* | / | *J-50* | *I-35+H-35* | *0* | / | *E-5 x 2* | / | *26* | *191* |
| *S4* | *E-35* | / | *J-50* | *I-35+H-35* | *20* | / | *E-5 x 2* | / | *12* | *212* |
| *S5* | *E-35* | / | *J-50* | *I-35+H-35* | *10* | / | / | / | *10* | *190* |
| *S6* | *E-35* | / | *J-50* | *I-35+H-35* | *0* | / | *E-5* | / | *29* | *189* |
| *S7* | *E-35* | / | *J-50* | *I-35+H-35* | *0* | / | *E-5* | / | *21* | *181* |
| | | | | | | | | | | |
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## PART J - SIZING OF SUPPLY DIFFUSERS, BRANCHES AND MAIN TRUNK DUCTS page 7

| J.1 Trunk Letter/No | E | | | | F | | | | A/B | C/D |
|---|---|---|---|---|---|---|---|---|---|---|
| J.2 Outlet location (Room) | Liv | Liv | Liv | | Bath | M/Bed | Kit | Bed 2 | | |
| J.3 Outlet No (S) | S1 | S2 | S3 | | S4 | S5 | S6 | S7 | | |
| J.4 Outlet flow rate (cfm) (Line D.6 ÷ D.7) (Heating) | 110 | 110 | 110 | | 44 | 131 | 100 | 59 | | |
| J.4b Outlet flow rate (cfm) (Line D.4 ÷ D.7) (Cooling) | N/A | N/A | N/A | | N/A | N/A | N/A | N/A | | |
| J.5 Outlet size | 4 x 10 | 4 x 10 | 4 x 10 | | 4 x 10 | 4 x 10 | 4 x 10 | 4 x 10 | | |
| J.6 Outlet pressure loss (in. W.C.) | 0.03 | 0.03 | 0.03 | | .01 | .03 | .02 | .01 | | |
| J.7 S/A Plenum pressure (in. W.C.) (Line G.3) | 0.14 | 0.14 | 0.14 | | 0.14 | 0.14 | 0.14 | 0.14 | | |
| J.8 Adjusted duct design pressure (J.7 - J.6) | 0.11 | 0.11 | 0.11 | | 0.13 | 0.11 | 0.12 | 0.13 | | |
| J.9 Branch effective length (ft) (Part I) | 181 | 193 | 191 | | 212 | 190 | 189 | 181 | | |
| J.10 Loss/100 ft of effective length [(J.8 x 100) ÷ J.9] | 0.06 | 0.06 | 0.06 | | 0.06 | 0.06 | 0.06 | 0.07 | | |
| J.11 Branch duct size (round) (J.4, J.10) (Appendix C4,5) | 7.0 | 7.0 | 7.0 | | 5.0 | 7.0 | 7.0 | 5.0 | 7.0 | 7.0 |
| J.12 Branch rectangular equivalent (Appendix C6) | N/A | ___ | ___ | | ___ | ___ | ___ | ___ | | |
| J.13 Trunk flow rate (cfm) accumulation of J.4 | 110 | 220 | 330 | | 44 | 175 | 275 | 334 | | |
| J.13b Trunk flow rate (cfm) accumulation of J.4b | N/A | ___ | ___ | | ___ | ___ | ___ | ___ | | |
| J.14 Lowest loss/100 ft encountered from duct end. | 0.06 | 0.06 | 0.06 | | 0.06 | 0.06 | 0.06 | 0.06 | | |
| J.15 Trunk duct size (round) (J.13, J.14) (Appendix C4,5) | 7.0 | 9.0 | 10.0 | | 5.0 | 8.0 | 10.0 | 10.0 | | |
| J.16 Trunk rectangular equivalent (Appendix C6) | N/A | ___ | ___ | | ___ | ___ | ___ | ___ | | |
| J.17 Installed Trunk size (Transitions) | ___ | ___ | 10.0 | | ___ | ___ | ___ | 10.0 | | |
| J.18 Trunk velocity (fpm) fpm = [(cfm x 144) ÷ area] | | | 605 | | | | | 612 | | |

## PART J - CONTINUED

page 8

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J.1 | | | | | | | | | | | | | | |
| J.2 | | | | | | | | | | | | | | |
| J.3 | | | | | | | | | | | | | | |
| J.4 | | | | | | | | | | | | | | |
| J.4b | | | | | | | | | | | | | | |
| J.5 | | | | | | | | | | | | | | |
| J.6 | | | | | | | | | | | | | | |
| J.7 | | | | | | | | | | | | | | |
| J.8 | | | | | | | | | | | | | | |
| J.9 | | | | | | | | | | | | | | |
| J.10 | | | | | | | | | | | | | | |
| J.11 | | | | | | | | | | | | | | |
| J.12 | | | | | | | | | | | | | | |
| J.13 | | | | | | | | | | | | | | |
| J.13b | | | | | | | | | | | | | | |
| J.14 | | | | | | | | | | | | | | |
| J.15 | | | | | | | | | | | | | | |
| J.16 | | | | | | | | | | | | | | |
| J.17 | | | | | | | | | | | | | | |
| J.18 | | | | | | | | | | | | | | |

# APPENDIX E
# ASSIGNMENTS

# E 1 Equipment Selection And Airflow Requirements:

**Assignment 1**

Design information:

- Total heat loss, - 47,000 Btuh.
- Total heat gain, - 23,000 Btuh.
- Volume of house, - 32,600 cu/ft.
- Equipment/fuel type, - H/E gas.
- Filter pressure drop (change), - + .04 in W.C.
- Equipment system ESP, - .80 in W.C.

Using the previous information, determine the following:

1. Heating equipment model & output.
   Model # ___________, ___________ Btuh.

2. Cooling equipment model & output.
   Model # ___________, ___________ Btuh.

3. Circulation airflow rate, _______ CFM.

4. Heating airflow rate, _______ CFM.

5. Cooling airflow rate, _______ CFM.

6. System design airflow rate, _______ CFM.

7. Available system pressure, _______ in W.C.

**Assignment 2**

Design information:

- Total heat loss, - 87,000 Btuh.
- Total heat gain, - 41,000 Btuh.
- Volume of house, - 46,600 cu/ft.
- Equipment/fuel type, - H/E Gas.
- Filter pressure drop (change), - + .06 in W.C.
- Equipment system ESP, - .80 in W.C.

Using the previous information, determine the following:

1. Heating equipment model & output.
   Model # __________, __________ Btuh.

2. Cooling equipment model & output.
   Model # __________, __________ Btuh.

3. Circulation airflow rate, _______ CFM.

4. Heating airflow rate, _______ CFM.

5. Cooling airflow rate, _______ CFM.

6. System design airflow rate, _______ CFM.

7. Available system pressure, _______ in W.C.

**Assignment 3**

Design information:

- Total heat loss, - 39,000 Btuh.
- Total heat gain, - 23,000 Btuh.
- Volume of house, - 36,600 cu/ft.
- Equipment/fuel type, - Air Handler with heat pump and Electric back-up.
- Filter pressure drop (change), - + .08 in W.C.
- Equipment system ESP, - .80 in W.C.

Using the previous information, determine the following:

1. Heating equipment model & output.
   Model # ___________, ___________ Btuh.

2. Cooling equipment model & output.
   Model # ___________, ___________ Btuh.

3. Circulation airflow rate, _______ CFM.

4. Heating airflow rate, _______ CFM.

5. Cooling airflow rate, _______ CFM.

6. System design airflow rate, _______ CFM.

7. Available system pressure, _______ in W.C.

8. Electric back-up heater, ______ kW.

# E 2 Mixed Air Temperature Calculations.

Determine the mixed air temperature calculations for the following examples.

**Assignment 4.**

- System design airflow rate 1200 CFM.
- Ventilation airflow rate 150 CFM.
- Return air temperature 68°F.
- O/A design temperature 5°F.

Mixed air temperature = ______ °F

**Assignment 5.**

- System design airflow rate 1000 CFM.
- Ventilation airflow rate 100 CFM.
- Return air temperature 68°F.
- O/A design temperature -30°F.

Mixed air temperature = ______ °F

**Assignment 6.**

- System design airflow rate 960 CFM.
- Ventilation airflow rate 110 CFM.
- Return air temperature 68°F.
- O/A design temperature 0°F.

Mixed air temperature = ______ °F

**Assignment 7.**

- System design airflow rate 750 CFM.
- Ventilation airflow rate 80 CFM.
- Return air temperature 68°F.
- O/A design temperature -15°F.
- HRV effectiveness 65%.

Mixed air temperature = ______ °F

**Assignment 8.**

- System design airflow rate 840 CFM.
- Ventilation airflow rate 200 CFM.
- Return air temperature 68°F.
- O/A design temperature -30°F.
- HRV effectiveness 75%.

Mixed air temperature = ______ °F

**Assignment 9.**

- System design airflow rate 1080 CFM.
- Ventilation airflow rate 140 CFM.
- Return air temperature 68°F.
- O/A design temperature 0°F.
- HRV effectiveness 60%.

Mixed air temperature = ______ °F

**Assignment 10**

Using question number 5; calculate the capacity of duct heater required to raise the mixed air temperature up to 65°F.

Formula: Btuh = CFM x 1.08 x temperature difference

_________ Btuh. _________ K.W.

# 5 GLOSSARY OF TERMS

*Terms in italics are defined elsewhere in this glossary.*

**Absolute Humidity or Humidity Ratio -**
the mass of water divided by the mass of air containing the water vapour.

**Air Barrier -**
any material used as to block the flow of air.

**Air Change -**
the sum of *air leakage* and *ventilation.*

**Air Change Rate -**
the number of times in one hour that the air is replaced in a space. Unit: air changes per hour (AC/h). 1 AC/h is the air flow rate which in 1 h would move a volume of air equal to the space.

**Air, Combustion -**
the air required for satisfactory combustion, including excess air, for a fuel burning *appliance.*

**Air, Exhaust -**
the air mechanically removed to the outdoors from a space, by such devices as kitchen fans, dryers, central vacuum cleaners, and not reused.

**Air, Flue Gas Dilution -**
the ambient air that is admitted to a *venting system* at the draft hood, *draft* diverter or *draft regulator.*

**Air Leakage -**
the uncontrolled exchange of air between the interior and exterior environments through unintentional openings in the *building envelope* under the influence of wind and buoyancy (*stack effect*) pressures. Infiltration and exfiltration are both components of air leakage. See Convection and Thermal Buoyancy.

Exfiltration -
uncontrolled air flow from inside to outside the building through cracks and gaps.

Infiltration -
uncontrolled air flow from outside to inside the building through cracks and gaps.

**Air, Make-up -**
*outdoor air* supplied to replace *exhaust air*, eg, by *infiltration*, *make-up air* duct, supply fan, etc. It does not include air entering the house as *combustion air* or to replace *exfiltration* air.

**Air, Outdoor -**
air from the external atmosphere, not previously circulated in the building. It is usually less contaminated than indoor air.

**Air, Recirculation -**
air removed from a space and then returned heated, cooled, humidified, etc.

**Air, Relief -**
air mechanically removed, passively exiting, or exfiltration from the house to reduce mechanically induced pressurization (opposite of *make-up air*).

**Air, Return -**
recirculation air being removed from a space.

**Air, Supply -**
recirculation air, with or without mixed *ventilation* air, injected into a space.

**Air / Vapour Barrier -**
any material used to block the flow of air and water vapour.

**Air, Ventilation (Supply) -**
*outdoor air* intentionally supplied by mechanical means to a *conditioned space.*

**Apparent Sensible Effectiveness (ASE) -**
the term used in the CSA C439M standard for testing *HRV*s to describe the temperature rise of *out-door air* passing through an *HRV.* The effectiveness includes the effect of motor heat gain, cross-leakage gain and casing gain. It is usually numerically higher than the *sensible recovery efficiency* of the HRV. When the flows of indoor and outdoor air through the HRV are equal, the *sensible recovery efficiency* equals the temperature rise of the outdoor air divided by the temperature difference between indoor and outdoor air entering the HRV, expressed as a percentage.

**Appliance (Heating)-**
a device to convert energy from fuel into heat energy, and includes any component, control, wiring, piping or tubing required to be part of the device.

**ASHRAE -**
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

**Aspect Ratio -**
the ratio of the width to the depth of a duct.

**B-Vent -**
a labeled, double-walled sheet metal *chimney* assembly, consisting entirely of factory-made parts, designed as "class B" according to the Gas Installation Code CGA B149.

**Backdrafting (Back Spillage) -**
flow reversal in a flue serving a fuel-fired *appliance*: the combustion products normally flowing up the flue are forced to reverse their course and discharge into the space occupied by the appliance.

**Barometric Damper -**
See Draft Regulator.

**Blower -**
a fan used to force air under pressure.

**Boiler -**
an *appliance* supplying hot liquid or vapour.

**Branch Duct -**
See Duct, Branch.

**British Thermal Unit (Btu) -**
the quantity of heat required to raise the temperature of 1 lb of water 1 Fahrenheit degree.
1 Btu/h = 0.2931W
1 W = 3.413 Btu/h

**Building Envelope -**
the surface formed by all components of the building which enclose the *conditioned space.*

**Burner -**
a device for the introduction of fuel, with or without air or oxygen, into the combustion zone for ignition.

**Natural draft:**
the burner is not equipped with a fan or *blower.*

**Fan assisted:**
the *combustion air* is supplied by a mechanical device such as a fan or *blower* at sufficient pressure to overcome the resistance of the burner only.

**Forced draft:**
the *combustion air* is supplied by a mechanical device such as a fan or *blower* at sufficient pressure to overcome the resistance of the burner and the *appliance.*

**cfm, CFM -**
cubic feet per minute, a measure of air flow.
1 cfm = 0.472 L/s or,
conventionally, 1 cfm = 0.5 L/s

**CFS -**
Commercial Fact Sheet.

**Chimney -**
a primarily vertical shaft enclosing at least one *flue*.

**Circulation Fan -**
usually the main *furnace blower* in a forced air system. Can be any ducted fan used to distribute *recirculation air* throughout the house. When the *ventilation* system is coupled to the forced air system this blower is required to be operable independently of the *furnace* heating and cooling cycle.

**Coaxial Vent -**
a combustion *appliance venting system* consisting of an inner pipe exhausting *products of combustion* within an outer pipe drawing in *combustion air*.

**Combustion Air -**
See Air, Combustion.

**Combustion Products or Gases -**
the constituents resulting from combustion of fuel with the oxygen of the air and includes inert gases that are part of the air, but not excess air.

**Comfort Zone -**
the range of effective temperature over which a majority (50% or more) of adults feel comfortable.

**Condensation -**
the process of changing a vapour into liquid by the extraction of *latent heat*.

**Conditioned space -**
any interior portion of the building that is intended to be heated, cooled or ventilated.

**Conductance, Thermal -**
the time rate of heat flow through unit area of a body, per unit temperature difference. Often called U-Value.
Units: Btu/(h ft² °F) or W/(m² °C)

**Conduction, Thermal -**
the process of heat transfer through a material from the hotter side to the cooler side.

**Convection -**
the transfer of heat that takes place within moving gases and liquids. An example is the heat carried by air after it has passed over a heating coil or heat exchanger in a heating unit. In a cavity in a wall, air heats and expands next to the warmer side, becomes lighter and rises. It is continuously replaced by a flow of cooler air from the opposite side. When the warmed air reaches the cooler side, it passes heat to the surface there and the circulation continues.

**Crawl Space -**
a shallow space below the living quarters of the basementless part of a house, normally enclosed by the foundation wall.

**CSA -**
Canadian Standards Association.

**Cubic Feet per Minute (cfm) -**
Imperial unit of airflow. 1 cfm = 0.472 L/s and 1 L/s = 2.12 cfm. In common practice, using 1 cfm = 0.5 L/s and 1 L/s = 2 cfm is close enough, though the error is technically about 6 %.

**Damper -**
a valve or plate regulating the flow of air in a duct.

**Damper, Barometric -**
See Draft Regulator.

**Degree-Day -**
For each day with a mean temperature below 18 °C (65 °F) the number of degree-days is this difference. These can be added up for a month or for a heating season. Used in calculating heating energy consumption.

**Delta T (ΔT) -**
the temperature difference across a building component:
for heating calculation, *IDT - ODT* ;
for cooling, *ODT - IDT*

**Depressurization -**
See Pressure, Negative.

**Design Temperature (2.5% basis) -**
the temperature used for sizing heating or cooling equipment. When actual temperatures go beyond the design temperatures, and there is no excess capacity in the equipment, thermal momentum will carry the building through these conditions for short periods, or a small degradation of comfort conditions can be expected.

**Winter Design Temperature -**
based on a 10 year average, the lowest sustained temperature that might be expected in normal winter conditions. The coldest month is January and 2.5% of the time in January the outdoor temperature may fall below the design temperature, but usually for only a short time.

**Summer Design Temperature -**
based on a 10 year average, the highest sustained temperature that might be expected in normal summer conditions. The warmest month is July and 2.5% of the time in July the outdoor temperature may rise above the design temperature, but usually for only a short time.

**Design Temperature Difference (DTD) -**
the difference between the indoor *design temperature* and the outdoor *design temperature.*

**Dew Point -**
the saturation temperature at which condensation of water vapour to visible water takes place. An example is the sweating on a glass of ice water. The cold glass reduces the air temperature below its dew point, and the moisture that condenses forms beads of water on the glass surface.

**Diffuser -**
the slotted or bladed guard at the room end of a *branch duct*, which may be equipped with a means of adjusting the aim of the flow of air.

**Dilution Air -**
See Air, Flue Gas Dilution.

**Direct Vent (sealed combustion) -**
applies to a type of fuel-fired *appliance* that takes its *combustion air* directly from the outdoors via a sealed passageway, and ejects its *combustion gases* outdoors as well, through an independent sealed *vent*, without ever using the indoor air of the building for combustion or venting.

**Distribution Effect -**
an increase to the *stack effect* resulting from the *depressurization* of the basement due to *return air* being sucked into leaks in a joist distribution system or through basement return air inlets.

**Draft -**
(1) the pressure difference which causes a current of air or gases to flow through a *flue, chimney*, heater or space.
(2) the flow of air, or *combustion products*, or both, through an *appliance* and its *venting system*.

(3) an uncomfortable localized feeling caused by one or more factors of high air velocity, low ambient temperature, or direction of air flow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

**Draft Control Device -**
either a *draft hood* or a *draft regulator*.

**Draft Hood -**
a draft control device having no moveable or adjustable parts. It may be built into or attached to an *appliance* or made part of a *vent connector*, and is designed to: (1) assure ready escape of *flue gases* from the combustion chamber if there is either no *draft* or stoppage downstream of the draft hood; (2) prevent a *back-draft* from entering the combustion chamber of the *appliance*; and (3) reduce the effect of stack action of a *chimney* or *vent*, when the *appliance* operates.

**Draft, Induced -**
a *mechanical draft* where the fan or *blower* is in the *flue gas* stream.

**Draft, Mechanical -**
a *draft* produced by a mechanical device such as a fan, *blower* or aspirator.

**Draft, Natural -**
a *draft* where the *combustion air* is supplied from within the building and the *products of combustion* are conveyed to the outdoors through a *chimney* or *B - vent*. This type of draft relies on *thermal buoyancy* to vent the combustion products. The upward force created by the buoyancy must be greater than any resisting forces in the *building envelope*. The force generated by the thermal buoyancy is proportional to the difference between the outdoor temperature and the flue gas temperature. This type of draft may be reversed, resulting in combustion spillage, if there is excessive negative pressure in the house or insufficient flue gas temperature.

**Draft Regulator (Barometric Damper) -**
a draft control device intended to stabilize the *natural draft* in an *appliance* by admitting room air to the *venting system*. A double-acting draft regulator has a balancing *damper* free to move in either direction.

**Dry Bulb Temperature -**
the temperature of air indicated by an accurate thermometer. This is the usual temperature to which people refer, but it is called "dry bulb" when it is necessary to distinguish it from *wet bulb temperature*. These two

temperatures are required for accurate calculation of *relative humidity*.

**Duct, Branch -**
a passageway carrying air to or from only one *register* or *grille*.

**Duct, Trunk -**
a passageway carrying the air to or from two or more *branch ducts*.

**Effective Length -**
in duct design, the length of a particular duct system path, equal to the total of the actual duct length and the *equivalent lengths* of the fittings in the flow path. Used in duct design.

**Equivalent Length -**
the length assigned to a duct fitting, expressed as the number of feet of straight smooth round duct of the same diameter as the fitting, which would have the same resistance to airflow.

**Equivalent Temperature Difference (ETD) -**
for cooling load calculations, the actual temperature difference across an opaque building assembly modified for the effect of the sun, according to the assembly's orientation, material, colour, and time of day.

**ESP -**
External Static Pressure. See Pressure, External Static.

**ETD -**
*Equivalent Temperature Difference.*

**Evaporation -**
the process of changing a liquid into a vapour by adding *latent heat.*

**Exfiltration -**
See Air Leakage.

**Exhaust Air -**
See Air, Exhaust.

**External Static Pressure -**
See Pressure, External Static.

**Feet per Minute (fpm) -**
Imperial unit of air velocity. 1 fpm = 0.00508 m/s and 1 m/s = 196.9 fpm. In common practice, using 1 m/s = 200 fpm is close enough, as the error is only about 1.6 %.

**Flue -**
an enclosed passageway for conveying *flue gases.*

**Flue Effect -**
the *infiltration* caused by the suction created by the rapid rising of *combustion gases* in a *chimney* using *natural draft.*

**Flue Gas Dilution Air -**
See Air, Flue Gas Dilution.

**Flue Gases -**
These are *combustion products* and excess air.

**Fluorescent -**
of a light source which provides light from an electrically excited but relatively cool coating.

**FMS -**
Flow Measuring Station.

**Forced Draft -**
See Burner, Forced Draft.

**Forced Draft Burner -**
See Burner, Forced Draft.

**Formaldehyde -**
a colourless, pungent gas used in solution as a strong disinfectant and preservative and in the manufacture of synthetic glues and UFFI.

**fpm, FPM -**
feet per minute, a measure of air velocity 1 fpm = 0.00508 m/s or, conventionally, 1 m/s = 200 fpm.

**Fresh Air -**
See Outdoor Air.

**Furnace -**
an indirect-fired, flue-connected, space-heating *appliance*, using warm air as the heating medium, and usually having provision for the attachment of ducts.

**Furnace Room -**
an enclosed space that contains a *furnace* and usually separates an open basement from the furnace.

**FWA -**
Forced Warm Air.

**Grade -**
the lowest of the average levels of finished ground adjoining each exterior wall of a building. Localized depressions such as for vehicle or pedestrian entrances need not be considered in the determination of average levels of finished grade.

**Grille -**
the slotted guard at the room end of a *branch duct*. Usually non-adjustable, and spoken of in reference to return air ducts.

**Habitable Space -**
space designed for human occupancy, such as a bedroom, living room, dining room, kitchen, family room, recreation room, or den.

**Head Drop -**
The vertical distance between the lower edge of an eave and the top edge of the outer surface of the window glass. This is the vertical component, which, with *overhang*, determines shading of a window.

**Heat Loss Factor (HLF) -**
for basements, a factor relating heat loss to the temperature difference and to dimensions which depend on the part of the building envelope being considered:
For walls below grade, its units are Btu/(h ft °F) or W/(m °C), where the length is the perimeter of the below-grade portion of the wall.
For floors below grade, its units are Btu/(h ft$^2$ °F) or W/(m$^2$ °C), where the area is the area of the below-grade floor.
These factors come from tables which take into account the depth below grade and the insulation added to the bare wall.

**Heat Reclaimer -**
a device installed externally or internally to a *venting system* to extract heat from *flue gases.*

**Heat Recovery Ventilator (HRV) -**
a factory assembled unit incorporating a means to circulate air for *ventilation* and a means to transfer heat between the incoming and outgoing air streams.

**HLF -**
Heat Loss Factor.

**Hood -**
a terminal in the exterior wall, floor or roof for the *outdoor air* inlet or the *exhaust air* outlet.

**HRAI -**
Heating, Refrigeration and Air Conditioning Institute of Canada.

**HRV -**
Heat Recovery Ventilator.

**Humidity Ratio -**
See Absolute Humidity.

**HVI -**
Home Ventilating Institute.

**IAQ -**
Indoor Air Quality.

**IDT -**
Indoor *Design Temperature.*

**Incandescent -**
of a light source which provides light from a white-hot electrically heated filament.

**Inches Water Column (or Gauge) -**
a measure of small pressure differences, equivalent to that obtained by observing the difference in height of the water levels in a U-tube whose ends are connected to the places having different pressures. Unit: in w.c. or Pa 1 in w.c. = 249 Pa, or, conventionally, 1 in w.c. = 250 Pa.

**Incident Radiation -**
*solar radiation* as it strikes a surface.

**Induced Draft -**
See Draft.

**Infiltration -**
See Air Leakage.

**Interpolation -**
finding a value from a table or list when the value used for reference falls between a pair of reference values of the table.

**Laminar Flow -**
a predictable parallel flow of air particles in a duct, occurring only at very low velocities, and offering less resistance than *turbulent flow.*

**Latent Heat -**
the energy involved in a change of state without a change in temperature. For example, to evaporate 1 lb of water to water vapour takes 970 Btu and condensing 1 lb of water vapour to water will release 970 Btu. All this happens while the temperature remains steady.

**Litres per Second (L/s) -**
metric unit of airflow. 1 L/s = 2.12 cfm and 1 cfm = 0.472 L/s. In common practice, using 1 L/s = 2 cfm and 1 cfm = 0.5 L/s is close enough, though the error is technically about 6 %.

**Make-up Air -**
See Air, Make-up.

**Mechanical Draft -**
See Draft.

**Minimum Ventilation Capacity (MVC) -**
in the CSA F326 standard, a capacity set by "room count", ie, 5 L/s per room but 10 L/s for the master bedroom, and 10 L/s for a basement area exceeding 2/3 of the total basement area. This is the same as the NBC's *Total Ventilation Capacity*.

**Mixed Air Temperature (MAT) -**
When *ventilation* is used, the temperature of the mixture of the *return air* and the *outdoor air* used for ventilation.

**MVC -**
Minimum Ventilation Capacity.

**Natural Draft -**
See Draft.

**Natural Ventilation -**
*outdoor air* supplied to a *habitable space* by natural forces through intentional openings such as open doors and windows, and by *air leakage* through unintentional cracks or holes.

**NBC -**
National Building Code of Canada, usually updated in years ending in 0 and 5, issued by the Canadian Commission on Building and Fire Codes, National Research Council of Canada.

**OBC -**
Ontario Building Code, usually updated after each edition of the *NBC* (National Building Code), issued by the Ontario Buildings Branch, Ministry of Housing of Ontario.

**ODT -**
Outdoor *Design Temperature*.

**OEL -**
Ontario Electrical League.

**Outdoor Air -**
See Air, Outdoor.

**Overhang -**
the horizontal distance an eave extends outward past the outer surface of the window. This is the horizontal component which, with *head drop*, determines shading of a window.

**Package Unit -**
an *appliance* supplied as a complete unit including controls and integral wiring.

**Packaged Ventilator -**

a factory assembled unit which has a means to supply *ventilation air* and/or to remove *exhaust air*, intended for continuous or intermittent operation, such as *HRV*s, ERV's and bathroom fans.

**Partition -**

any wall or floor separating conditioned zones in a commercial building.

**PEFC -**

Principal Exhaust Fan Capacity, in the OBC, a flow determined by the number of bedrooms.

**Power Venter -**

a device to provide *mechanical draft* installed between the *appliance* and the *vent* termination.

**Pressure Drop -**

the *static pressure* loss caused by air flow through a duct, filter coil, *HRV* core, etc..

**Pressure, External Static (ESP) -**

The negative *static pressure* in a *return air* plenum is interconnected with the positive static pressure in the supply plenum of a unit such that when they are added together, they become the total external static pressure of the unit. The unit external static pressure is the motive force that the blower will exert, after overcoming the internal resistance of the filter and casing, to propel the air to be circulated through the supply and return air ducts.

**Pressure, Negative (depressurization) -**

the condition of lower air pressure inside the house than outside. It happens when the amount of air removed from the house exceeds the amount supplied by mechanical or other means. *Outdoor air* is sucked in through any openings in the *building envelope*, which may include the *chimney*.

**Pressure, Positive (Pressurization) -**

the condition of higher air pressure inside the house than outside. It happens when the amount of air supplied to the house exceeds the amount removed by mechanical or other means. Excess air is forced out through any openings in the *building envelope*.

**Pressure, Static -**

the pressure available between the inside and outside of a duct; a measure of pressure available from a fan to move a given amount of air or the pressure required to use or deliver a given amount of air across a resistance (for example, a filter, coil, length of duct, etc.).

**Pressurization -**
See Pressure, Positive.

**Principal Exhaust Fan -**
a fan intended to be able to remove air from a home continuously. An *HRV* can be a principal exhaust fan.

**Products of Combustion -**
See Combustion Products.

**R-2000 -**
A Canadian performance standard for efficiency in housing including testing airtightness using pressurizing equipment.

**R-Value -**
See Resistance, Thermal.

**Radiation -**
the transmission of heat energy which occurs by means of electro-magnetic waves whenever two surfaces at different temperatures face each other.

**Recirculation Air -**
See Air, Recirculation.

**Register -**
the slotted guard at the room end of a *branch duct,* equipped with a *damper* or other means of regulating and/or aiming the flow of air.

**Relative Humidity -**
the ratio of the amount of water vapour in the air to the greatest amount that could be in it at the same temperature, expressed as a percent.

**Relief Air -**
See Air, Relief..

**Resistance, Thermal -**
often called R-Value, the reciprocal of thermal conductance (ie, R = 1/U). Units: (h ft$^2$°F)/Btu or (m$^2$ °C)/W. The resistances of adjacent components of an assembly, eg, a wall, may simply be added to find the total resistance of the assembly. Heat loss or gain due to conduction is then the product of the area and temperature difference, divided by the R-Value.

**Return Air -**
See Air, Return.

**Return Air Ceiling Plenum -**
the space above the finished ceiling, and below the roof or floor above, used for the collection of air from the space

below the ceiling for cycling through the conditioning system.

**Safety Limit Control -**
a safety control intended to prevent an unsafe condition of temperature, pressure or liquid level.

**SC -**
See Solar Correction.

**Sealed Combustion -**
See Direct Vent.

**Sensible Heat -**
heat that will change the temperature of a substance without changing its state. Sensible heat is measured with a thermometer. Water that is heated from 20°C (68°F) to 35°C (95°F) does not change its state. It remains a liquid. Because this change in temperature can be read with a thermometer, the heat involved is sensible heat. The reverse is also true: if the water is cooled, the amount of heat removed is sensible heat.

**Sensible Recovery Efficiency (SRE) -**
the term used in the CSA C439M standard for testing *HRV*s to describe the net energy recovery during winter heating conditions. It is corrected for the effect of motor heat gain, defrost energy, cross-leakage gain and other effects like casing gain. It is usually numerically lower than the *apparent sensible effectiveness* of the HRV.

**Shading Factor (SF) -**
a geometric factor, dependent on latitude and orientation, used to calculate the shading effect of an *overhang* on a window.

**SI -**
the official international abbreviation of the name for the modern metric system of measurement. It stands for Le Système international d'unités.

**SMACNA -**
Sheet Metal and Air Conditioning Contractors' National Association, Vienna, Virginia.

**Solar Correction (SC) -**
an amount to be added (though the number is sometimes negative) to the cooling $\Delta T$ to allow for the solar radiation effect and mass effect for walls and roofs.

**Solar Heat Gain Factor (SHGF) -**
for cooling load calculations, a factor expressing heat gain per unit area across a glazed building assembly, according

to the assembly's orientation, the construction of the building, and the time of day.

**Solar Radiation -**
the energy arriving in a direct line from the sun in the form of light and heat, warming any object in its path.

**Specific Heat -**
the quantity of heat required to change the temperature of a substance by one degree. 1 Btu is required to change the temperature of 1 lb of water 1°F, or in the SI, 1.16 Wh is needed to change the temperature of 1 kg of water 1°C.

**Stack Effect -**
The tendency of warm air which has risen to the top in a building (because it is lighter) to escape through cracks and be replaced by colder air from outside which infiltrates through lower openings. The overall result is a continuous flow, with *exfiltration* occurring upstairs and *infiltration* occurring downstairs. At some point, where the air flow changes from an outward to an inward direction, there is no pressure difference between inside and outside. This can be described as a flat surface cutting across the building and dividing it into two parts: one with high pressure and one with low pressure, relative to the outdoors. This dividing plane is known as the "neutral pressure plane".

**Static Pressure -**
See Pressure, Static.

**Supplemental Exhaust -**
the exhaust required in addition to the *principal exhaust fan* capacity (PEFC) to equal the *total ventilation capacity* (TVC). It may be provided by one or more of a higher speed of the principal exhaust fan or the *HRV*, or kitchen, range hood, bath or water closet fans.

**Supplementary Heating -**
may be used in finished basements and/or basement walk-out areas; may be supplied by any type of thermostatically controlled heating source.

**Supply Air -**
See Air, Supply.

**Terminal Velocity -**
for a diffuser, a velocity of about 50 fpm, used to define the extent of the throw of the diffuser.

**Thermal Buoyancy -**
the result of a gas being warmer than a larger body of gas to which it is connected. The warmer body of gas is lighter and will seek to rise relative to the larger body. In houses it

is evident in the action of *natural draft chimneys* and in the *stack effect*.

**Thermal Conductance -**
See Conductance, Thermal.

**Thermal Resistance -**
See Resistance, Thermal.

**Thermal Storage -**
the delayed release of heat absorbed from *solar radiation* by objects within a *conditioned space* and by the surfaces enclosing it.

**Total Pressure -**
although a non-existent pressure, this term expresses the sum of *static* and *velocity pressures*.

**Total Ventilation Capacity (TVC) -**
in the *NBC*, the minimum combined capacity of the *ventilation* system(s) installed, calculated by a "room count": 5 L/s per room but 10 L/s for the master bedroom, and 10 L/s for a basement area which exceeds 2/3 of the total basement area. This is the same as the CSA F326 standard's *Minimum Ventilation Capacity*.

**Trunk Duct -**
See Duct, Trunk.

**Turbulent Flow -**
an irregular swirling flow of air particles in a duct, occurring at all but very low velocities, and offering more resistance than *laminar flow*.

**TVC -**
*Total Ventilation Capacity*.

**Type B Vent -**
See B-Vent.

**U-Value -**
See Conductance, Thermal.

**UFFI -**
Urea Formaldehyde Foam Insulation, a form of insulation foamed into place in cavities until much alarm was raised on its suspected harmful effects on human health.

**ULC -**
Underwriters' Laboratories of Canada.

**VAV (Variable Air Volume) -**
an air distribution system used in commercial projects where a constant volume of air circulates through the ductwork, but controlled variable amounts are bled to the spaces to be conditioned.

**Velocity Pressure -**
a pressure equivalent for the kinetic energy of a moving air stream, convertible to *static pressure.*

**Vent -**
that portion of a *venting system* designed to convey *flue gases* directly to the outdoors from a *vent connector* or an *appliance* when a vent connector is not used.

**Vent Connector -**
that part of a *venting system* that conducts the *flue gases* from the *flue* collar of an *appliance* to a *chimney* or *vent*, and may include a *draft control device.*

**Ventilation -**
the controlled exchange of air between the interior of a building and its surroundings. It can be provided by bathroom and kitchen exhaust fans, dryer vents and all other mechanical devices that expel air or allow air into the structure.

**Ventilation Effect -**
the *infiltration* caused by the suction created by operation of exhaust devices such as bathroom fans, clothes dryers and central vacuum systems.

**Ventilation Supply Air -**
See Air, Ventilation Supply.

**Venting System -**
a system for removing *flue gases* to the outdoors by means of a *chimney, vent connector, vent* or a natural or mechanical exhaust system.

**Watt -**
the *SI* unit of power.
1 W = 3.413 Btu/h

**Wet Bulb Temperature -**
the temperature indicated by the wet-bulb thermometer of a psychrometer. Used, with the dry bulb temperature, for calculation of *relative humidity.*

**Wind Effect -**
the *infiltration* on the windward side of a building and the *exfiltration* on the leeward side, caused by pockets of higher and lower pressure outside the building when the wind blows.